COVER SHEET

State of the Art Report into the use of ICPM in the Construction Industry

Report 2001-008-C-01

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Research Program C:
Delivery and Management of Built Assets

Project 2001-008-C:
Project Team Integration: Communication, Coordination and Decision Support

CONTENTS

CONTENTS ii
LIST OF FIGURES vi
LIST OF TABLES viii
PREFACE ix
EXECUTIVE SUMMARY x
Construction Industry x
International Statistical Indicators x
Industry's Need for Technological Innovation and Change xi
E-Commerce in Construction xi
ICT Adoption within the Construction Industry – Case Studies xi
ICT Adoption Advantages, Drivers, Barriers, and Implementation Challenges xi
Future Trends and Recommendations xii
Conclusion xii
1 INTRODUCTION 1
2 PROJECT 2001-008-C: PROJECT TEAM INTEGRATION: COMMUNICATION COORDINATION AND DECISION SUPPORT 4
2.1 Project Background 4
2.2 Project Business Basis 4
2.3 Research Objective 5
3 USE OF COMPUTERS, WWW & INTERNET 7
3.1 Australian Businesses (2001) 7
3.1.1 By Business Size 7
3.1.2 By Region 8
3.1.3 By Industry 8
3.1.4 By State 9
3.2 Australian Government (2000 - 2002) 12
3.3 Australian Business and Government (2000-2001) 13
3.4 Government (1998) 13
3.4.1 Government e-Tender 15
3.4.2 Other Technologies 16
3.5 International Comparison 18
3.5.1 Australia v Canada - Private Sector Businesses & Internet Commerce 20
3.5.2 Australia v Nordic countries 22
3.5.3 Australia v the United Kingdom (UK) 22
3.5.4 E-Government Rankings 22
4 INDUSTRY'S NEED FOR TECHNOLOGICAL INNOVATION & CHANGE 24
4.1 Forces of Change 24
4.2 Types of Innovation 24
4.3 Competitive Re-engineering 24
4.4 Performance and Cost 25

4.5 Organisational Integration 25
5 E-BUSINESS / COMMERCE 26
5.1 Categories 26
5.2 In Construction 28
6 KEY CASE STUDIES 29
6.1 Case Study 1: Technology – Enhanced Project Management - USA 29
6.2 Case Study 2: Web-based Decision Support Systems - USA 30
6.3 Case Study 3: Online Remote Construction Management - Australia 31
6.4 Case Study 4: Web-based Construction Document Processing via Malleable Frame - USA 33
6.5 Case Study 5: Planning for Computer Integrated Construction - South Korea 35
6.6 Case Study 6: Strategic Implementation of IT/IS Projects in Construction: a Case Study - Australia 36
6.7 Case Study 7: Information Technology Planning Framework for Large-Scale Projects - USA 38
6.8 Case Study 8: Simplified Spreadsheet Solutions: Subcontractor Information System (SIS) - Canada 40
6.9 Case Study 9: Project-Specific Web Sites: Friend or Foe? - UK 40
6.10 Case Study 10: Project Management (PM) in Construction: Software Use and Research Directions - USA 41
6.11 Case Study 11: Technology Adoption Decisions in Construction Organisations - USA 41
6.12 Case Study 12: Anticipating Reuse: Documenting Buildings for Operations using Web Technology - USA 43
6.13 Case Study 13: Trying to Improve Communication and Collaboration with Information Technology – New Zealand 45
6.14 Case Study 14: Humanistic Redesign and Technological Politics in Organisations - Australia 47
7 ADVANTAGES OF ICT ADOPTION 49
7.1 General 49
7.2 Project Level 50
7.3 SME Professionals and Consultants 50
7.4 Cross Sector 51
7.5 e-Construction 53
7.6 Knowledge Management (KM) 54
7.7 Quality Management (QM) 55
7.8 Government and the Internet 57
8 DRIVERS OF ICT ADOPTION 59
8.1 Organisational 59
8.2 ICT System Performance 60
9 ICT IMPLEMENTATION BARRIERS AND CHALLENGES 62
9.1 Australian Business Organisations 62

9.2 Construction Industry Organisations 63
9.3 Choosing the Correct Implementation Strategy 63
9.4 e-Construction 64
9.5 Information Overload and 'Gatekeepers' 65
9.6 Project Related Failures 65
9.7 Inadequate Information Management 67
9.8 Culture 67
9.8.1 Industry 68
9.8.2 ICT 68
9.8.3 International 70
9.8.4 Additional Culture Classifications 71
9.9 Technology Driven Change 71
9.10 Culture Driven Change - Technology Is Not Enough 73
9.10.1 Invest in People 74
9.10.2 Trust in Project Teams 76
9.11 Resistance to Technological Change 77
9.12 Training 78
9.12.1 e-Training 79
9.13 e-Security 79
9.14 Government Barriers of Internet Use 79
10 FUTURE TRENDS AND RECOMMENDATIONS 81
10.1 Construction Industry 81
10.2 Technological Change 84
10.3 Paper to Electronic 86
10.4 Competitive Drive 87
10.5 Virtual teams 87
10.6 Improved ICT Implementation / Application and Commitment to Change 88
10.7 e-Commerce and Construction 90
10.8 Interoperability 91
10.9 e-Trends 91
10.10 e-Solutions 92
10.11 e-Security 93
10.12 Culture 94
10.13 Training and Education 94
10.14 Strategic, Technological and Project Innovation 95
10.15 Innovation through Knowledge Management 97
10.16 Nanotechnology in Construction 98
10.17 Government 99
10.18 Research and Development (R&D) 99
11 CONCLUSION 101
12 BIBLIOGRAPHY 116

13 GLOSSARY 123

14 APPENDICES 125

Appendix A: ABS Survey Comparisons 126

Appendix B: Additional Organisational Cultures 127
B-1. Core Culture: 127
B-2. Culture Tribes: 128
B-3. Culture Themes: 128
B-4. Dimensions of Culture: 129
B-5. Classic v Quantum Culture: 129
B-6. Culture Metaphors: 130

Appendix C: Virtual Team Research Propositions 132

Appendix D: e-Solutions 134

15 AUTHOR BIBLIOGRAPHIES 137

LIST OF FIGURES

Figure 1-1: What Is Needed for Better Construction Performance 2
Figure 3-1: Australian Businesses Using IT 7
Figure 3-2: Business Use of IT (By Region) – June 2001 8
Figure 3-3: Business Use of IT (By Industry) – June 2001 9
Figure 3-4: Business Use of IT (By State) – June 2001 10
Figure 3-5: Internet Activity (By State) A – September 2001 10
Figure 3-6: Internet Activity (By State) B – September 2001 11
Figure 3-7: Percentage (%) and Type of Australian Government Services (2001) 13
Figure 3-8: Government Use of PCs and the Internet – June 1998 14
Figure 3-9: Government Use of PCs – June 1998 15
Figure 3-10: Government Forms / Tenders via the Internet – June 1998 16
Figure 3-11: Other Technologies Use by Government – June 1998 17
Figure 3-12: Summary of Country Ranking and % Scores – April 2002 19
Figure 3-13: Canada v Australia: Businesses Using IT – 2000-01 21
Figure 3-14: Canada v Australia: Internet Commerce – 1999-2001 21
Figure 3-15: Australia v Nordic Countries: Internet Access & Web Presence - 2000-01 22
Figure 3-16: International E-Government Rankings and % Scores - 2001 23
Figure 5-1: e-Commerce Categories 26
Figure 5-2: Additional e-Commerce Categories 27
Figure 5-3: eCommerce Process Model 28
Figure 6-1: Traditional v ORCM Information & Communication System 31
Figure 6-2: ORCM Best Practice Recommendations 32
Figure 6-3: Web-Based Front-End Integration 34
Figure 6-4: Proposed CIC Framework 35
Figure 6-5: Strategic IT/IS Implementation Framework for Construction Organisations 36
Figure 6-6: IT Strategic Planning Framework 39
Figure 6-7: Documentation Process 44
Figure 6-8: Five Stage Action Research Cycle 46
Figure 6-9: Process Configuration to Effectively Influence the Design of Technologies 48
Figure 7-1: ICT Benefit and Impact 49
Figure 7-2: QM Process 56
Figure 7-3: ICT Use and Impact on QM Process 57
Figure 7-4: Government Advantages of Internet Use – June 1998 58
Figure 8-1: Drivers of Change 61
Figure 9-1: Parallel Operations 63
Figure 9-2: Total Conversion 63
Figure 9-3: Phased Implementation 64
Figure 9-4: Pilot Implementation 64
Figure 9-5: Triangle of Dependences 67
Figure 9-6: Strategy for Developing Five ICT Cultures 69
Figure 9-7: International Organisational Cultures 71
Figure 9-8: Organisational Performance Framework – Technical & Social Structure 72
Figure 9-9: Industry Business Challenges 75
Figure 9-10: Business Case for Commitment to People 76
Figure 9-11: Government Barriers to Internet Use 80
Figure 10-1: Total Construction Activity – Australia: 1999-2009 81
Figure 10-2: Total Residential Building Activity – Australia: 1999-2009 82
Figure 10-3: Total Non-Residential Building Activity – Australia: 1999-2009 83
Figure 10-4: Total Engineering Construction Activity – Australia: 1999-2009 83
Figure 10-5: Disruptive Events (Change) - Causing a 'Quantum Shift' 85
Figure 10-6: Model of Group Effectiveness 88
Figure 10-7: Innovative Drivers and Technological Diffusion 96
Figure 10-8: Industry Critical Success Factor – Knowledge Management 97

Figure 10-9: Knowledge / Idea Development Process 98
Figure 11-1: ICT Use across the 10 Phases of a Construction Project 102
Figure 14-1: Corporate Culture ‘Tribes’ 128

LIST OF TABLES

Table 3-1: Fourteen Key Countries across Twenty-Three Statistical Indicators (2002) 18
Table 6-1: Push v Pull Information Distribution 40
Table 6-2: Decision-Making Processes 43
Table 6-3: Examples of Generic Formats 44
Table 7-1: Knowledge and Project Process Development Advantages and Benefits 52
Table 7-2: Four Organisational Learning Levels 54
Table 9-1: Affects of 'Disruptive' ICTs 62
Table 9-2: Four ICT Implementation Strategies Compared 64
Table 9-3: Construction Industry 'Personalities' 68
Table 9-4: Five ICT Cultures 69
Table 9-5: International Organisational Cultures 70
Table 9-6: Forces of Resistance to Organisational Change 77
Table 9-7: Technological Change Force-field Analysis 78
Table 10-1: Cultural Effects When Implementing a Technological Change 94
Table 10-2: Nanotechnology in Construction 98
Table 11-1: Key to Figure 11-1 103
Table 13-1: Definitions 123
Table 14-1: 'Core' Cultures 127
Table 14-2: Corporate Culture 'Tribes' Defined 128
Table 14-3: Classic v Quantum Culture 129
Table 14-4: Animal Cultures 130
Table 14-5: Virtual Team Research Propositions 132

PREFACE

The Cooperative Research Centre – Construction Innovation (CRC-CI) research project 2001-008-C: *'Project Team Integration: Communication, Coordination and Decision Support'*, is supported by a number of Australian industry, government and university based project partners including: Queensland University of Technology (QUT); Commonwealth Scientific Industrial Research Organisation (CSIRO), University of Newcastle; Queensland Department of Public Works (DPW); and the Queensland Department of Main Roads (DMR).

This *'State of the Art Report into the Use of ICPM in the Construction Industry*' has been prepared for the CRC-CI, as required under the various CRC-CI, QUT and Industry Partner research agreements. Whilst all due care and attention has been taken to establish the accuracy of the material published, authors disclaim liability for any loss, which may arise from any person acting in reliance upon the contents of this document.

EXECUTIVE SUMMARY

The main objectives of the Internet-based Construction Project Management (ICPM) component of CRC-CI Project 2001-008-C (Project Team Integration: Communication Coordination and Decision Support), aim to demonstrate leadership in facilitating the use of online technologies for the design, management and construction of building and civil construction projects. The project aims to identify and implement appropriate information and communication technology (ICT) solutions that will improve resource management; support and integrate total project life cycle considerations; increase efficiencies on projects; ultimately reduce overall cost and improve project outcomes to project participants in the public and private sectors. The project will demonstrate the benefits and efficiencies obtained through ICPM thereby stimulating improvements and encouraging the wider adoption of such processes in the AEC industries (Section 1).

Supporting the above research aims and objectives, the 2001-008-C '*State of the Art Report into the Use of ICPM in the Construction Industry*' represents an 'snapshot' of current industry practices and research directions in the implementation and application of ICPM/ICT tools and systems.

Construction Industry

Construction is one of the most important industries in any developed country, facing a period of rapid and unparalleled change in the next 20 years, moving it in new directions:

- from paper to electronic media;
- from local to global commerce;
- from a management to a leadership focus; and
- from a reactive to a proactive state.

(Russell J.S. 2000)

Issues of poor communication, information transmission, coordination and teamwork are the cause of most of the performance problems in the construction industry. A stream of industry reports, from the UK, USA, Australia and other countries, covering the past 4 decades have reinforced this. The failure to achieve significant improvements in what are well-identified issues can be linked to the hitherto limited capacity to conceptualise and manage the very complex dynamics in project processes throughout the project's life cycle.

Consequently, there is an urgent and vital need to address those key issues that will most significantly influence the construction industry and the way in which it contributes to our society and the economy as a whole in the future.

International Statistical Indicators

Section 2 of the report provides encouraging, though varying, international industry and government statistical indicators, rankings, and comparisons for the use of a range of ICPM and ICT solutions during the 1998-2002 periods. Research indicates the use of personal computers (PCs), local and wide area networks (LAN / WAN), data storage devices, email, Internet, World Wide Web (WWW) and other ICT tools and systems, make it possible for individuals and businesses to (economically) create, process, transmit and store information electronically (Schelberg N.S. and Weinstein S.D. 1999).

Industry's Need for Technological Innovation and Change

Briefly touching on the forces of change; types of innovation; re-engineering and organisational integration, Section 3 further highlights the success of technological developments, in terms of uptake and usage, can only be improved on if the conditions of innovation diffusion within project organisations, parent organisations, and the broader industry are understood and brought into play. This includes the matching of technological innovation with the perceived needs and preparedness for change on the part of the industry.

E-Commerce in Construction

The Internet has debatably revolutionised the way in which information is stored, exchanged and viewed, opening new avenues for businesses, which were only a decade ago almost inconceivable. Current and future ICT developments (particularly in e-Commerce) and its applicability and uptake within the construction industry, is causing virtually every business sector to shift away from or 'radically alter' traditional, tried and tested methods of communications (Anumba C.J. and Ruikar K. 2002). Section 4 of the report provides a brief outline of six main e-Commerce categories identified during the investigation, namely:

- Business-to-Business (B2B)
- Business-to-Consumer (B2C)
- Business-to-Administration (B2A)
- Consumer-to-Administration (C2A)
- Consumer-to-Consumer (C2C)
- Administration-to-Administration (A2A)

Further, although the industry is identified as embracing/making use of various Internet tools and systems (in several different ways), research indicates, it is still slow (overall) in e-Commerce adoption when compared to other engineering sectors (such as the automotive or aerospace industry). The restricted uptake is mainly due to the:

- fragmented nature of the industry; and
- one-off nature of its projects.

ICT Adoption within the Construction Industry – Case Studies

There are numerous examples of ICT implementation as well as research and development (R&D) activities within the Australian and international construction industry. Arguably, current levels of ICT adoption within the construction industry vary from country to country. Presented in Section 5 of the report are fourteen (14) key case study summaries of such ICT implementation, adoption and R&D activities within the industry. The case studies presented are not exhaustive - only covering a small yet relevant sample of current research activities within Australia, New Zealand, UK, USA, Canada and South Korea.

ICT Adoption Advantages, Drivers, Barriers, and Implementation Challenges

Measuring benefits, barriers and challenges of innovative ICT solutions and their implementation within the construction industry is not easy - mainly due to there being numerous methods of evaluation (none with a consistent approach within or across industry organisations) – several are based on traditional investment appraisal techniques (primary financial ratios) and others adopt a more subjective approach. Nonetheless, Sections 6 and 7

of the report attempt to identify, if only a handful of advantages and drivers to ICT adoption within the industry under the following sub-headings:

- General
- Project level
- SME professionals and consultants
- Cross sector
- e-construction
- Knowledge & Quality management
- Government
- Organisational
- ICT system performance

Further, Section 8 of the report identifies a range of barriers and challenges individual businesses, Governments, and industry organisations could be faced with during the implementation and application of innovative ICT tools and systems. Research investigations include:

- Some indicative statistics of affects, risks, and barriers to adoption, implementation, and 'cross-sector' use of ICTs in construction industry organisations.
- Identifying and comparing four ICT implementation strategies for organisations and user(s) to consider.
- Identifying construction organisation challenges and e-Commerce barriers.
- Briefly identifying causes of information overload and restrictions to information flows.
- Defining the term 'failure' and identifying various failure factors on projects.
- Providing a brief outline to various causes of limited approaches to managing project related information.
- Defining and comparing certain industry, ICT and international culture types, personalities, etc.
- Discussing the importance and difficulty of 'aligning' technology (ICT) solutions with people (culture).
- To ensure successful ICT implementation within organisations, there is a need for cultural change by 'investing in people' (not only technology), and by trusting project teams.
- Additional investigations identify the driving and restraining forces to technological change; the industry's need for training; ICT security issues; and statistical indicators pertaining to the Australian Government and its barriers to internet use.

Future Trends and Recommendations

The report provides a range of future industry trends and recommendations in Section 9 pertaining to the construction industry; technological change; paper vs. electronic communications; competition; virtual teams; e-Commerce; interoperability; security; culture; training; innovation and knowledge management; nanotechnology; government; and research and development (R&D).

Conclusion

It is been over 40 years since the introduction of ICT tools and systems into the construction industry, yet organisations are still unable to obtain the many potential benefits of ICT investment - many years after the initial expenditures have been incurred. Furthermore, the industry has been identified as 'slow' in embracing innovative ICT tools and systems such as eCommerce, e-Conferencing, Internet and Intranets (Stewart R.A., Mohamed S. et al. 2002).

The acquired knowledge about ICT and other cultures is proven to be a valuable aid to industry organisations, managers and other participants who are charged with making effective use of ICT. Research suggests that all industry organisations recognise the difficulty of implementing change due to the ‘persistence of enduring values and assumptions that are deeply rooted in human experience’. Cultures cannot be ‘designed'. Cultures overlap, producing tensions of opportunity for gradual cultural and technical change. Although unable to effect such changes directly, organisations (management) need to adjust / revise formal ICT policies by implementing stricter controls over ‘user initiatives’ rather than maintain dominant values (Kaarst-Brown M.L. and Robey D. 1999).

With regard to e-Commerce, it will underpin further growth in the Australian economy as it enables innovation and significant advances in productivity and efficiency within and across industry sectors. The e-Commerce market has seen significant changes over the last two years, focusing on moving beyond the technology and towards how these tools can make business processes and relationships more efficient. The implementation challenges of e-Commerce are also more widely recognised. There is increasing evidence that companies can realise the benefits of e-Commerce by collaborating to work on whole-of-industry solutions and standards (APCC 2001).

Finally, the pace of change - said to be fast and all embracing - will create more and greater business opportunities than ever before, both at home and overseas. It will be highly dependent on a changed cultural thinking, information sharing, customer-centric thinking, electronic commerce and co-operation at every level throughout an integrated supply chain. (Foresight 2000).

INTRODUCTION

Construction is one of the most important industries in any developed country, facing a period of rapid and unparalleled change in the next 20 years. Consequently, there is an urgent and vital need to address those key issues that will most significantly influence the construction industry and the way in which it contributes to our society and the economy as a whole in the future.

To ensure all industry participants fully benefit from these 'impacts' and advances requires a continuing and significant shift in practices and attitudes within the industry and in the quality it delivers. It also needs to overcome existing problems with customer dissatisfaction and improve the way its capability is perceived and understood by both public and private sectors (Foresight 2000).

The industry is at a critical point in its history, with many 'divides' being created, moving it in new directions (Russell J.S. 2000):

- from paper to electronic media;
- from local to global commerce;
- from a management to a leadership focus; and
- from a reactive to a proactive state.

Once these 'divides' are crossed, 'new realities' will be realised in certain trends of the construction industry. The following trends, said to be reshaping the industry as we currently know it, signifies design and construction industry members must work together if they are to become and / or remain leaders in a competitive, global market place:

- **Fully integrated and automated project processes**: a seamless delivery process - with no disconnects between planning, design, procurement, construction, and operation and maintenance. Empowered, cross-discipline teams will incorporate expertise from designers, contractors, specialty contractors, vendors, suppliers, and operations and maintenance staff. The industry has passed through the 'Industrial Revolution' and the 'Agricultural Revolution', and is now in the 'Information Revolution'. Today, virtual design teams, computer- aided design / computer-aided construction; virtual reality; animation; the World Wide Web (WWW); e-mail; and electronic commerce and data interchange are commonly understood and used.
- **Owner requirements modifying the roles of the designer and the contractor**: Owners expect safely constructed products, which are built quickly and economically to a specified quality and are operated and maintained efficiently. The roles of the owner, the engineer, and the contractor are changing in response to such project delivery systems as design/build, design/build/warrant, design/build/operate/maintain, and finance/design/ build/operate. 'One-kind-fits-all' delivery systems no longer work in the fluid global marketplace, and performance- based specifications will continue in the next millennium.
- **Globalisation of the industry**: In the late 1950s, contract awards were made on a competitive bid basis. In the 1970s and 1980s, however, there was a significant shift to international markets because:
  - domestic economics (oil and real estate) reduced construction demand;
  - owners began outsourcing rather than performing design and construction themselves;
  - design and construction technologies were transferred to Third World countries; and
  - owners moved their manufacturing to expanding markets.

  In the 1990s many mergers, acquisitions, and ownership changes that publicly traded companies would never have contemplated 25 years ago took place. The is said to be heading toward the globalisation of design engineering (round-the-clock engineering), materials, equipment, and labour - with importing from the Third World.
- **Increased role of suppliers**: Business results accrue through a supply chain. To better integrate, plan, and schedule, as well as achieve maximum quality and ability to evaluate

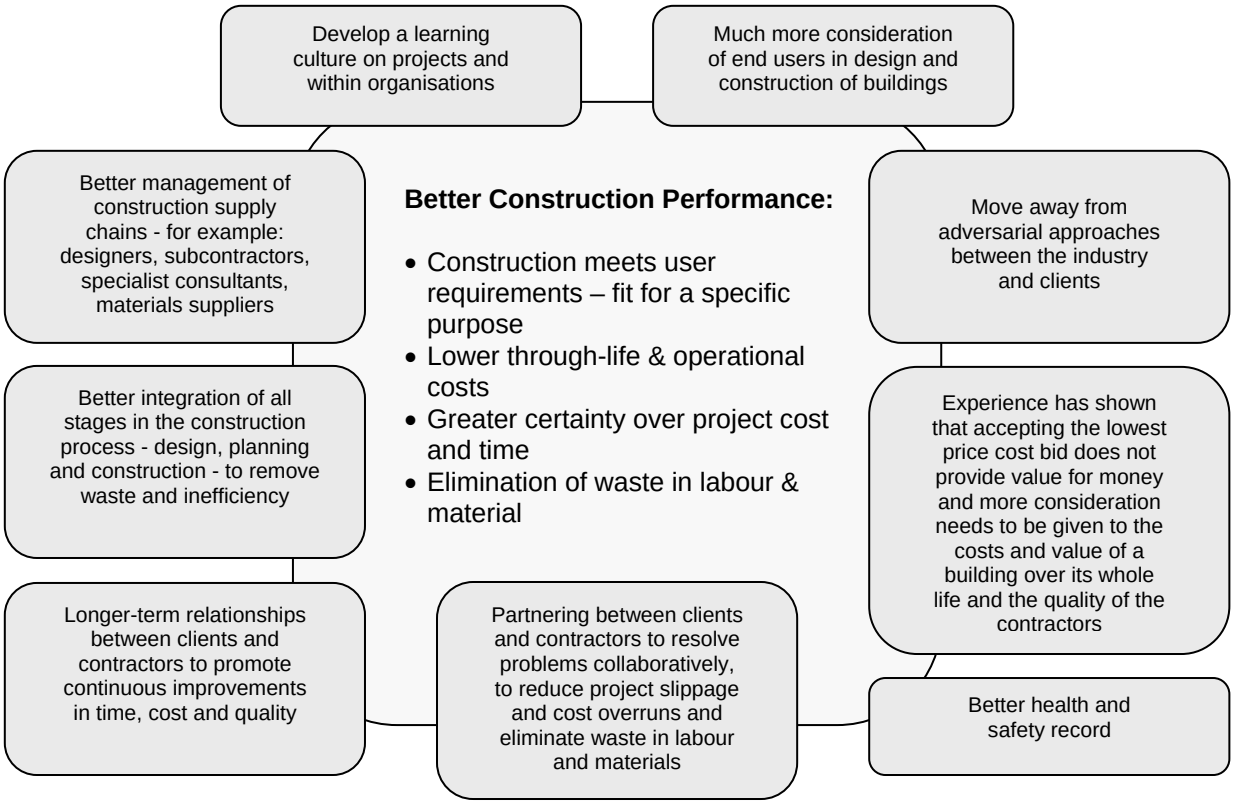
economic options, all parties need to be engaged as early as possible in project planning when essential decisions need to be made.

- **Reduced project cycle time**: '*time is money*' - Industry organisations (large and small) must understand the economics of capital investment and be innovative in organising themselves to meet the increasingly stringent demands of the owner.
- **Changes in skilled workforce**: Attracting, training, and retaining a motivated, skilled workforce are essential to successfully meeting the demands on the construction industry. An industry wide marketing plan is suggested to recruit the men and women who actually build our projects.

Information and communication technology (ICT) is not used sufficiently in today's construction industry and rarely in an integrated way – i.e.: potentially improving the quality of building designs and making the process more cost effective (from tender stage through design and construction) with full electronic communications between the client, design team and operational staff.

Research findings indicate the need for a greater concentration on achieving a better construction that meets the needs of the end user at a lower lifecycle costs. The entire supply chain including clients, professional advisers, contractors, sub-contractors and suppliers of materials must be integrated to manage risk and apply value management and engineering techniques to improve 'buildability' and drive waste out of the process (Figure 0-1). This process should reduce lifecycle and operational costs, lead to greater certainty of project time and budgeted costs, fewer accidents and more sustainable construction (NAO 2001).

Figure 0-1: What Is Needed for Better Construction Performance



Additionally, current ‘secretive’ organisational cultures (where information, seen as a source of power, influence, and importance – only made available on a need-to-know basis) are to transform themselves into more ‘open cultures’ where an atmosphere of mutual trust and respect occurs by organisations. This allows operational information, planning and decision making processes (e.g.: deciding whether or not to implement an innovative ICT tool or system) to be made available to both employers and employees alike (whilst maintaining some degree of control) (Baines A. 1998).

1 PROJECT 2001-008-C: PROJECT TEAM INTEGRATION: COMMUNICATION COORDINATION AND DECISION SUPPORT

1.1 Project Background

Issues of poor communication, information transmission, coordination and teamwork have been identified as the cause of most of the performance problems in the construction industry. A stream of industry reports, from the UK, USA and Australia, covering the past 4 decades have reinforced this. The failure to achieve significant improvements in what are well-identified issues can be linked to the hitherto limited capacity to conceptualise and manage the very complex dynamics in project processes throughout the project's life cycle.

Relatively recent developments in information and communication technology, the science of complexity, and the conceptualisation of systemic solutions in constructability research provide the scope to achieve a quantum improvement in project performance by facilitating better communication, coordination and decision support among project participants through the whole project life cycle.

The success of technological developments, in terms of uptake and usage, can be improved if the conditions of innovation diffusion within project organisations, parent organisations, and the broader industry are understood and brought into play. This includes the matching of technological innovation with the perceived needs and preparedness for change on the part of the industry.

The linking of key offices and the personnel and data sources held there with the site office enables design and other information to be transmitted and downloaded, from both ends. Currently, information is often 'lost' in the sense that vital information is not retained for easy re-use and must be re-entered, or bulky manuals and drawing folios must be carried, to ensure the employee working out of the office has rapid access to the information needed to perform some of their tasks. Further, the nature of construction projects requires team members to attend the construction site to resolve issues that arise during the design, documentation, and construction stages of a project. Australia, in particular, is a large country with dispersed projects and team members usually headquartered in the major cities and regional centres – extensive travel is therefore necessary, with inefficiencies in time and delays in decision-making. Innovative techniques allowing collaboration across a wide area network between the consortiums will promote rapid resolution of outstanding project issues as well as reducing the need for personnel to spend unnecessary travel time.

Project communications that make extensive use of online or IT-based technology, including Collaborative Computer-supported Design and Construction (CCDC) and Internet-based Construction Project Management (ICPM), have the potential:

- for saving considerable time during the various design and construction stages;
- improving design and documentation quality - due to benefits such as less re-entering of data amongst the design team; less correcting of drawings because of miss-understanding or miss-timing of changes; less checking because of the common database; and less seeking of irrelevant details (Kajewski S. and Weippert A. 2000).

1.2 Project Business Basis

Globally, the construction industry plays an important part in economic development (Industry Science Resources 1999). The Australian construction industry, through the end

products it creates, its size and ability to create employment, has the potential to influence the country's GDP more than any other service industry (Love P.E.D., Tucker S.N. et al. 1996).

The New South Wales Government comments that a $10 million project with monthly cash flows of $500,000 might have as many as 50 contracts, 5 different consultants, 200 tenders, 600 final drawings, 3,000 amended drawings, 150 contract variations, 600 site instructions, and 6 meetings per week. The use of appropriate IT would be invaluable in improving the efficiency and productivity of such projects. Further, the New South Wales Government indicates that even a 1% improvement in productivity on their annual expenditure of approximately $6 billion could fund the equivalent of 1 major hospital or 20 primary schools per annum. Nationally, the construction industry is valued at approximately $30 billion per annum and with preliminary studies indicating that with appropriate utilisation of IT a 1% improvement in productivity may be conservative, the potential benefit for the construction industry is considerable. Some research indicates that when considering the entire project process, project delivery duration may be shortened by up to 30% (NSW Department of Public Works and Services 1998).

There presently exists within the Australian AEC industries a considerable lack of knowledge about ICT systems and other available technologies, which may prove beneficial in the procurement, delivery and life cycle asset management of projects (Kajewski S. and Weippert A. 2000).

1.3 Research Objective

The objectives of the ICPM component of the research undertaking aims to demonstrate leadership in facilitating the use of online technologies for the design, management and construction of building and civil construction projects. It aims to identify and implement appropriate communication and information technology solutions that will improve resource management, support and integrate total project life cycle considerations, increase efficiencies on projects, ultimately reduce overall cost and improve project outcomes to project participants in the public and private sectors.

The project will test, field trial and/or evaluate information and communication systems allowing the above issues to be addressed, evaluated and studied in depth. In particular, the project will establish case study projects that will foster the expansion of communication and information technologies in the building and civil construction sectors, thus stimulating the use of such technologies in public and private building and infrastructure projects. This will result in an increase in information technology knowledge, awareness and skills of companies in both the public and private sector.

Most state government 'Public Works' departments are moving towards or investigating IT-based systems for their building and construction management systems. It is most likely that e-Tendering, e-Communication and e-Archiving will become a prerequisite for engagement on government project over the next 5 to 10 years. In addition, many major contractors and consultants are developing their own 'project web portals' to capture the benefits that arise from real-time communication, problem solving and shared project information databases. Some research has already been completed in examining the public sector adoption of ICPM processes. In Australia, however, this research tends to be confined to the New South Wales Department of Public Works. While other such organisations are examining the adoption of such technologies and processes the knowledge and collective wisdom tends to be incomplete. Further, this knowledge is not commonly available in the public domain. This project will examine national and international activities currently undertaken and develop a comprehensive state-of-the-art knowledge-base and best-practice guidelines suitable for national adoption.

The project will demonstrate the benefits and efficiencies obtained through Internet-based Construction Project Management (ICPM) thereby stimulating improvements and encouraging the wider adoption of such processes in the AEC industries. Through this adoption, projects will be delivered in a timelier and cost efficient manner. The project will also demonstrate the potential for the use of hand-held technologies/applications in the industry by examining the existing and emerging technologies not yet embraced by the AEC industries.

The project is also concerned with the upstream and downstream phases of projects. e-Tendering and e-archiving is often touted as the future for the AEC industries. The project will determine the state-of-play concerning e-Tendering and e-archiving and will ascertain the barriers and enablers from both a technological and legislative perspective.

2 USE OF COMPUTERS, WWW & INTERNET

In the past, older and more expensive technologies did not allow information to be stored in a (Schelberg N.S. and Weinstein S.D. 1999):

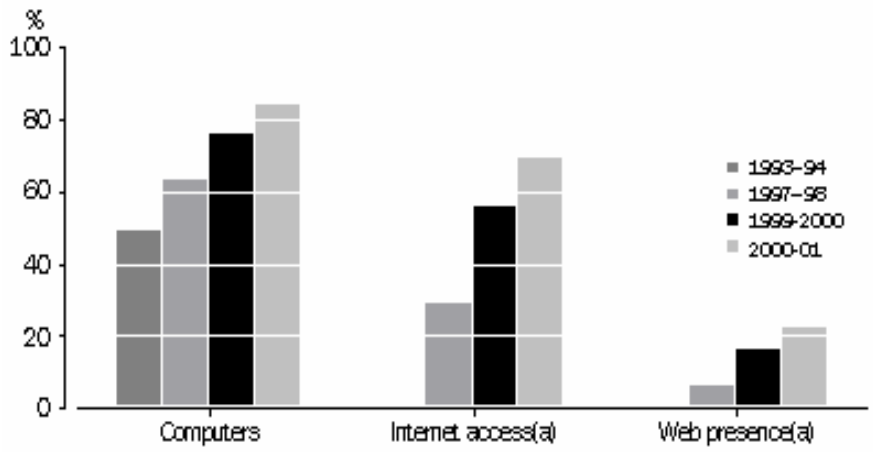
- cost-effective manner; or
- form that clearly replicated a printed copy of the document saved.

Today, personal computers (PCs), local and wide area networks (LAN / WAN), data storage devices, email, Internet, World Wide Web (WWW) and other ICT tools and systems have made it possible for individuals and small businesses to (economically) create, process, transmit and store information electronically. Advanced backup equipment, imaging and graphics technology and the dramatic reduction in the price of electronic storage technology, have made it possible for individuals and their organisations to cost-efficiently store documents and information in an electronic format (Schelberg N.S. and Weinstein S.D. 1999).

2.1 Australian Businesses (2001)

The number of Australian businesses using computers, accessing the Internet and using web sites or home pages continues to grow (Figure 2-1). Computer use has shown steady growth – i.e.: rising from 49% of Australian businesses (1993-94) to 84% of businesses at the end of June 2001. In contrast, the proportion of businesses with a Web presence has grown rapidly i.e.: rising from 6% (1997-98) to 16% (1999-2000) and 22% (2000-01). The proportion of businesses with Internet access has also risen rapidly, from 29% (1997-98) to 56% (1999-2000) and 69% (2000-01) (ABS 2002).

Figure 2-1: Australian Businesses Using IT



Extract from (ABS 2002)

Note:
(a) – Data not collected for 1993-94

2.1.1 By Business Size

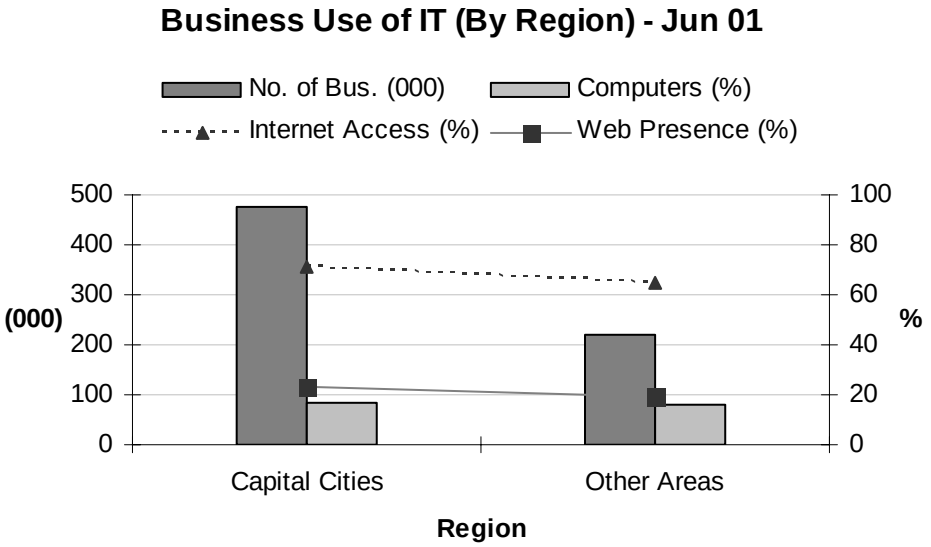
A strong relationship exists between the employment size of a business and the likelihood that the business is using IT. As employment size increases, so does the proportion of

Australian businesses making use of IT – e.g. at end June 2001, majority of large businesses (those employing 100 or more persons) used computers (100%) or had access to the Internet (99%), while 81% had a Web presence. In contrast, small businesses (those employing fewer than 5 persons) had a lower level of IT adoption; 79% used computers, 64% had access to the Internet and only 14% had a Web presence (ABS 2002).

2.1.2 By Region

There were only minor regional differences in the use of IT at the end of June 2001. as shown in Figure 2-2, minor differences were recorded in the proportion of businesses with Internet access (71% in capital cities and 65% in other areas) and lessor differences in the proportion of businesses using computers (84% and 82% respectively). Even the proportion of businesses with a Web presence showed only a modest difference between businesses in capital cities (23%) and those in other areas (19%) (ABS 2002).

Figure 2-2: Business Use of IT (By Region) – June 2001

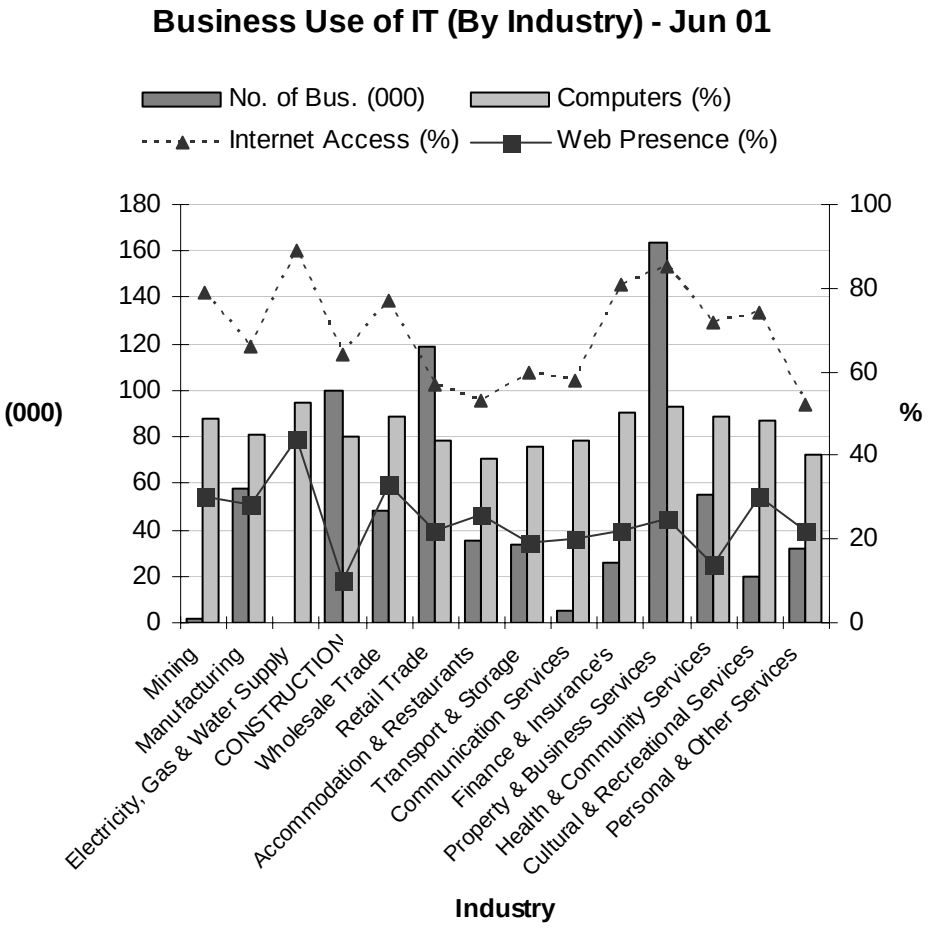


2.1.3 By Industry

At the end of June 2001, the proportion of Australian businesses using information technologies varied considerably across industries (Figure 2-3) (ABS 2002):

- The proportion of businesses using (a)computers or (b)with access to the Internet was recorded lowest in the:
  - 'Accommodation, cafes and restaurants' industry: (a)71% and (b)53%; and in the
  - 'Personal and other services' industry: (a) 72% and (b) 52%.
- Computer and Internet use was recorded highest in the 'Electricity, gas and water industry' (95% and 89% respectively).
- The highest proportion of businesses with a Web presence was also verified in the 'Electricity, gas and water industry' (44%), while the lowest proportion was in the *Construction industry* (10%).

Figure 2-3: Business Use of IT (By Industry) – June 2001



2.1.4 By State

At the end of June 2001, the proportion of Australian businesses using information technologies and the Internet varied considerably at a state level (Figure 2-4, Figure 2-5 and Figure 2-6) (ABS 2002):

Figure 2-4: Business Use of IT (By State) – June 2001

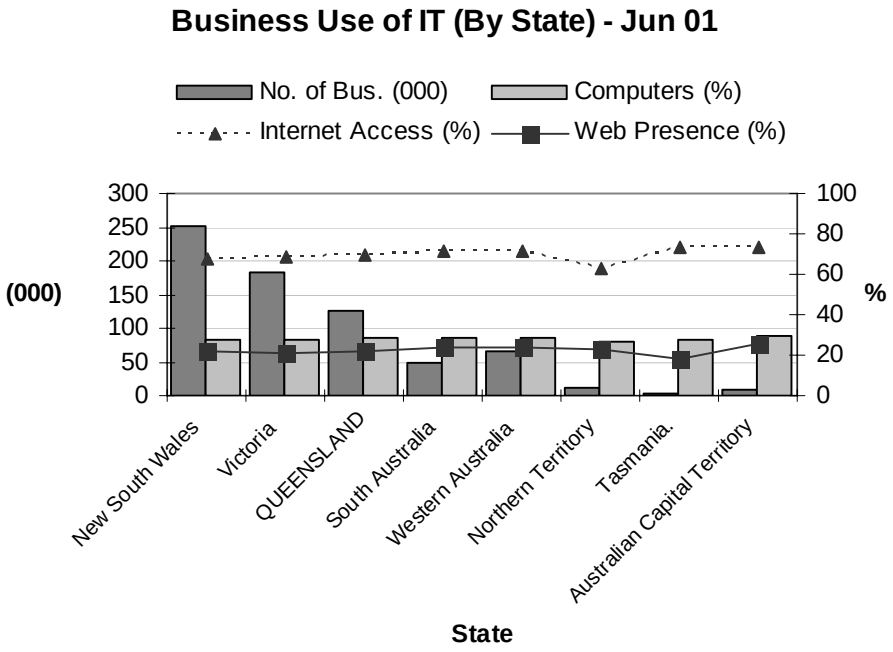
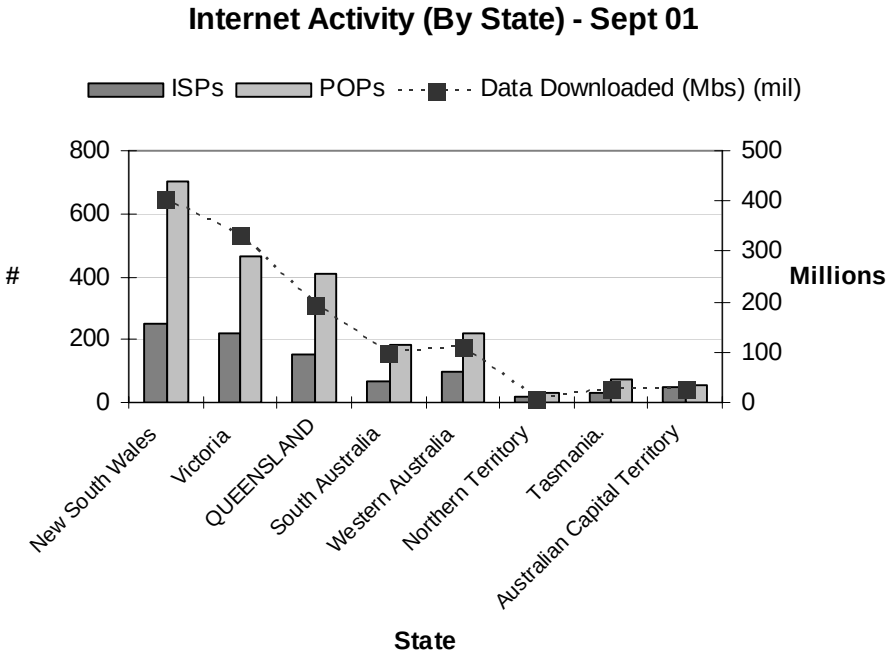
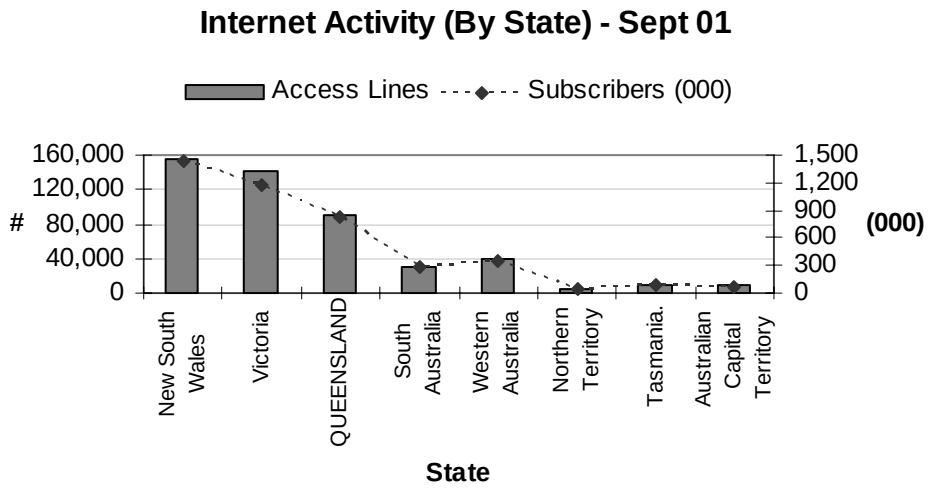


Figure 2-5: Internet Activity (By State) A – September 2001



Note:
POP is a server in a geographical location where a subscriber can access (connect to) an internet service provider (ISP) via access lines (ABS 2002).

Figure 2-6: Internet Activity (By State) B – September 2001



Key to Figure 2-4, Figure 2-5 and Figure 2-6

- **New South Wales:**
  - ISPs decreased by 16;
  - POPs decreased by 33;
  - access lines increased by 12,169;
  - subscribers increased by 132,000; and
  - data downloaded by subscribers increased by 11 million Mbs.
- **Victoria:**
  - ISPs decreased by 4;
  - POPs increased by 6;
  - access lines decreased by 487;
  - subscribers increased by 21,000; and
  - data downloaded by subscribers increased by 5 million Mbs.
- **Queensland:**
  - ISPs decreased by 14;
  - POPs decreased by 21,
  - access lines decreased by 9,313;
  - subscribers decreased by 36,000; and
  - data downloaded by subscribers decreased by 22 million Mbs.
- **South Australia:**
  - ISPs decreased by 3;
  - POPs increased by 5;
  - access lines decreased by 555;
  - subscribers decreased by 12,000; and
  - data downloaded by subscribers decreased by 1 million Mbs.
- **Western Australia:**
  - ISPs decreased by 7;
  - POPs decreased by 13;
  - access lines decreased by 594;
  - subscribers decreased by 16,000; and
  - data downloaded by subscribers decreased by 3 million Mbs.
- **Northern Territory:**
  - ISPs decreased by 2;

- POPs decreased by 2;
- access lines decreased by 28;
- subscribers increased by 4,000; and
- data downloaded by subscribers remained constant at 9 million Mbs.

- **Australia Capital Territory:**
  - ISPs decreased by 3;
  - POPs decreased by 5;
  - access lines increased by 1,215;
  - subscribers increased by 2,000; and
  - data downloaded by subscribers increased by 1 million Mbs.
- **Tasmania:**
  - ISPs remained constant at 28;
  - POPs increased by 3;
  - access lines decreased by 305;
  - subscribers decreased by 2,000; and
  - data downloaded by subscribers increased by 7 million Mbs.

2.2 Australian Government (2000 - 2002)

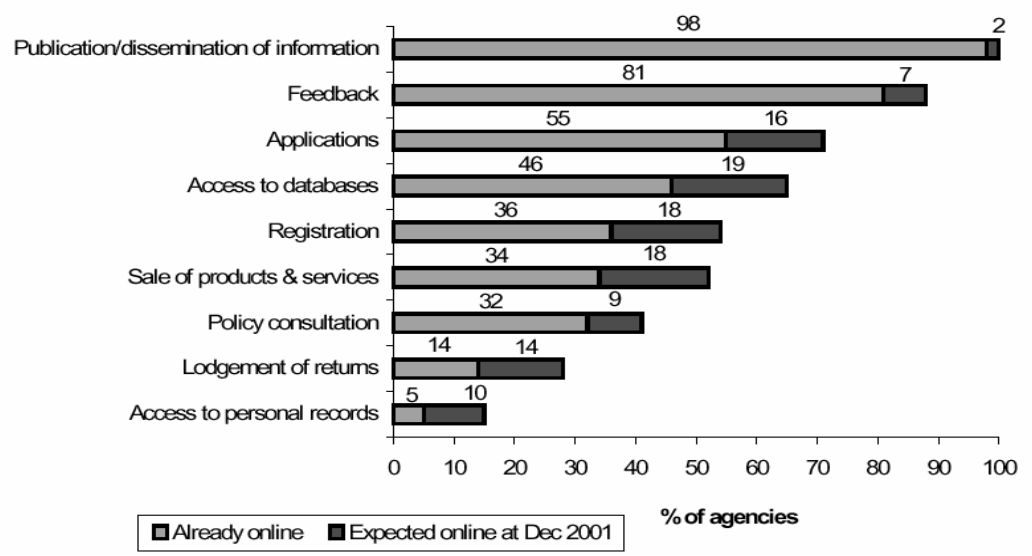
The Commonwealth Government has announced a 'whole-of-government portals framework' to provide a customer-focused coordinated approach to the Commonwealth's online presence. This framework will facilitate 'cross-agency services' and capture opportunities that exist in the online environment – i.e.: to tie together information and services (typically delivered separately), providing efficiency benefits for both users and government. The first nine portals were to be online by August 2001, with a further nine established by June 2002. The portals are based on customer groupings and topics (e.g.: first nine portals are: business; regional; youth; families; education; agriculture; culture & recreation; science & industry; and employment) (NOIE 2001).

Today's Government departments / agencies offer a wide range of (current and anticipated) e-Commerce facilities / services, greatly reducing administrative and other costs (Section: 4). Current Government services (via the Internet) include (Ecommerce 2002):

- placing procurement processes online;
- allowing private companies to bid for calls to tender;
- selling of publications, surplus supplies, property and licences;
- facilitating citizens to vote;
- submit applications; as well as
- register for services, etc.

All government agencies were expected to publish / disseminate information online with the majority (88%) expected to have 'feedback capacity' by the end of 2001 (Figure 2-7). Six of the nine service types shown were expected to be available on the majority of agencies' web sites by the end of 2001 (NOIE 2001).

Figure 2-7: Percentage (%) and Type of Australian Government Services (2001)



Extract from (NOIE 2001)

Furthermore, the number of agencies offering online access to databases, registration and sale of products / services is expected to increase (NOIE 2001), effecting / influencing current and future relationships between public and private sectors through (Ecommerce 2002):

- improved efficiencies and reduced costs (both public and private);
- increased transparency;
- decreased inconsistency, loss or misplacement of information, applications and documentation (automated electronic record); and
- less likelihood for corruption (particularly in weak economies).

2.3 Australian Business and Government (2000-2001)

From July 1999 to June 2000, 25% of Australian businesses (with employees) accessed government services online (NOIE 2001):

- The vast majority of government agencies (94%) pay at least some of their suppliers electronically;
- A quarter of these agencies (26%) pay more than 71% of their suppliers electronically; and 7% pay more than 90% electronically.
- However, 60% of agencies pay fewer than half their suppliers electronically.

By the end of December 2001, 87% of government agencies were expected to conduct simple procurements using open standards (e.g. 'Open Buying on the Internet' and XML standards). At the time of the survey, 18% of these were already in a position to do so (NOIE 2001).

2.4 Government (1998)

This section covers the Australian Government's IT and Internet activities for periods 1997-98. The 1999 - 2000 issue of ABS Catalogue No. 8119.0 - Government Use of Information

Technology (released 28 May 2002) is not referred to in this document as it only covers the Australian Government's IT&T Expenditure and IT Employment for that period.

Figure 2-8 and Figure 2-9 presents the use of information technology and telecommunications (IT&T) by government organisations (1997-98 financial years), indicating the use of PCs being high for all levels of government, i.e.:

- 100% of Federal and State/Territory departments and agencies;
- 100% of local government; and
- 94% of other government organisations using PCs at the end of June 1998 (ABS 1999).

Access to the Internet (June 1998):

- highest for Federal departments and agencies (100%); followed by
- State/Territory (85%) - of which 97% with 20 or more employees;
- local government (77%); and
- other government (60%).

Of the 1,798 government agencies:

- 73% had access to the Internet,
- 898 (37%) had a web site / home page at the end of June 1998:
  - 89% Federal;
  - 61% State / Territory;
  - 28% local government; and
  - 21% other government.

Additionally, access to the Internet varied directly with the size of the organisation:

- 56% of organisations (employing 1-19 persons); and
- 78% for organisations (employing 20-99 persons); compared with
- 100% larger organisations (employing 5000 or more persons).

Figure 2-8: Government Use of PCs and the Internet – June 1998

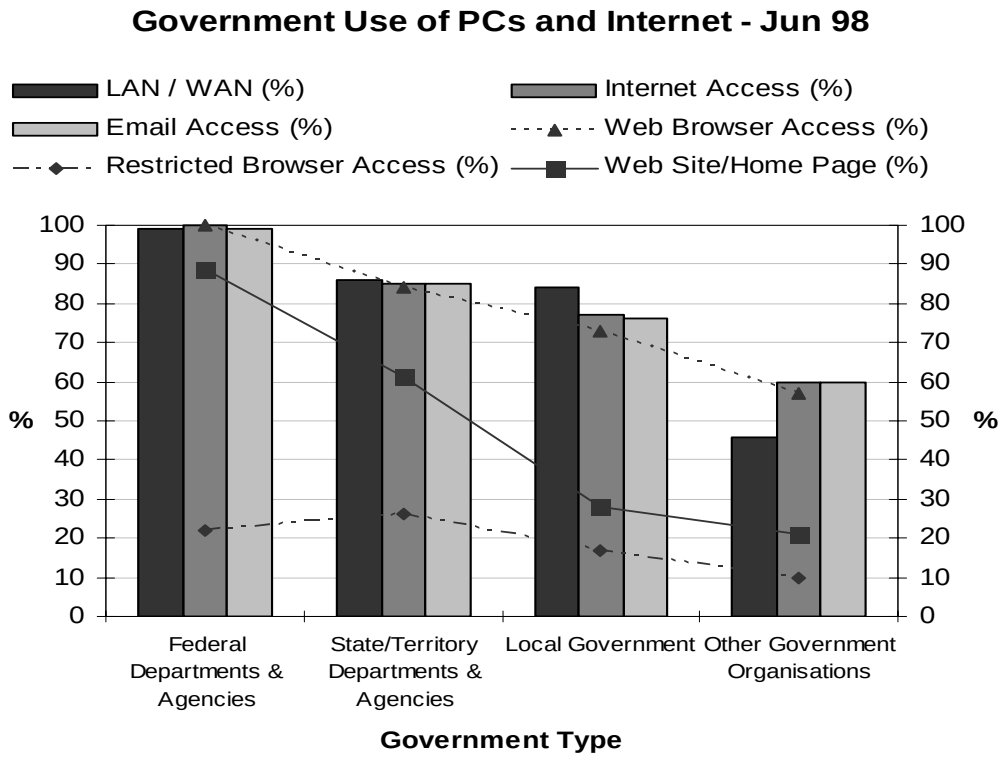
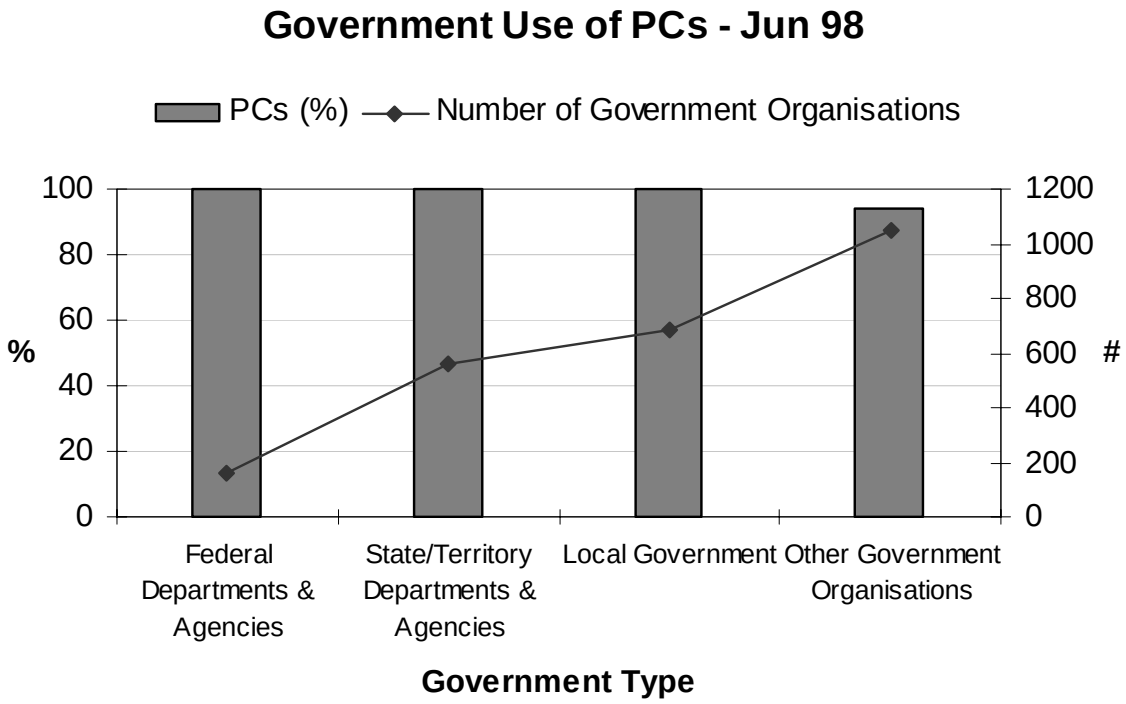


Figure 2-9: Government Use of PCs – June 1998



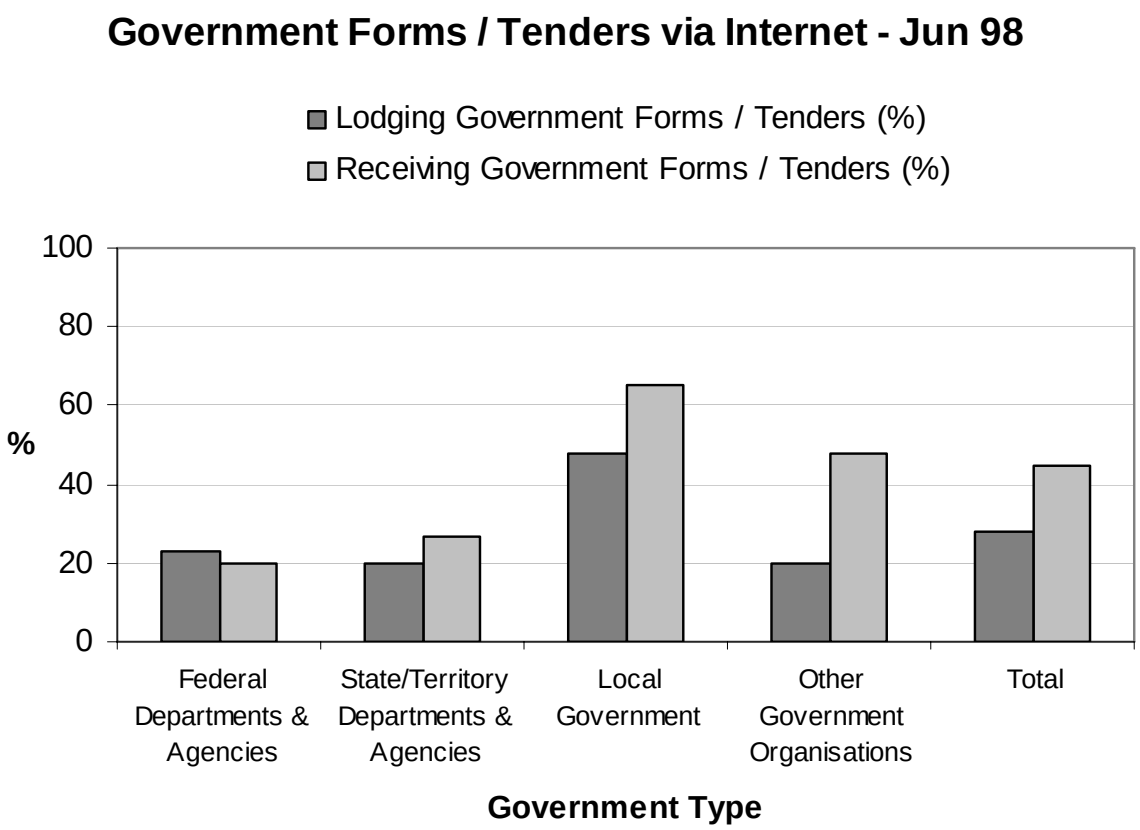
The following 'types' of government classify Government organisations in Figure 2-8 and Figure 2-9 (above

- **Federal departments and agencies:** defined as Australian Government Departments, Australian Government Legislature, Courts, Australian Government Industry and Marketing Boards and Australian Government Statutory Authorities.
- **State/Territory departments and agencies:** defined as State/Territory Government Departments, State/Territory Government Legislature, Courts, etc, State/Territory Government Industry and Marketing Boards and State/Territory Government Statutory Authorities including essential services agencies.
- **Local government:** defined as Local Government Authorities, and Aboriginal and Torres Strait Islander Community Councils.
- **Other government organisations:** defined as Federal, State/Territory and local government organisations not included elsewhere, including government owned companies.

2.4.1 Government e-Tender

At the end of June 1998, Government organisations (with access to the internet) recorded limited use of the internet for receiving and lodging government tenders / forms (Figure 2-10) (ABS 1999).

Figure 2-10: Government Forms / Tenders via the Internet – June 1998

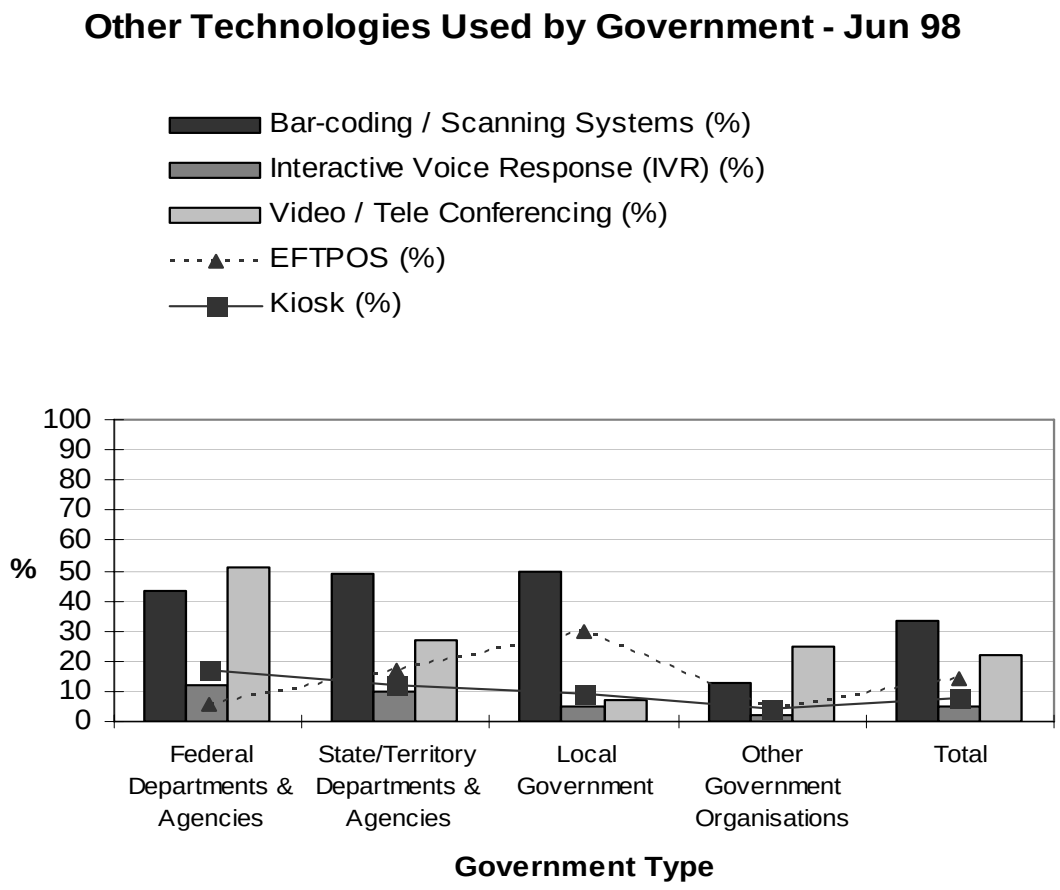


2.4.2 Other Technologies

At the end of June 1998 (Figure 2-11):

- 33% of government organisations used bar-coding / scanning systems;
- 22% used video conferencing / teleconferencing;
- 8% offered kiosk facilities;
- 5% used interactive voice response (IVR);
- 14% offered EFTPOS facilities:
  - usage was highest in local government (30%); compared to
  - less use in Federal and State / Territory departments and agencies (6% and 17% respectively).

Figure 2-11: Other Technologies Use by Government – June 1998



Note:

- *Bar-coding/scanning systems: Commonly used for tracking inventory and pricing goods e.g. a business scans the product barcode to read the price of the product into the cash register.*
- *Interactive Voice Response (IVR): An automated process of dealing with clients, e.g. recorded phone messages that direct the caller to dial a specific number/s to enable a specific activity to occur.*
- *Video conferencing/teleconferencing: Refers to a method of 'live' two-way video and audio communication.*
- *Electronic Funds Transfer Point of Sale (EFTPOS): a method of purchasing/making payments (i.e. a method for performing a financial transaction).*
- *Kiosk: Includes all public access devices: databases of information, which can be accessed by the public to obtain general and specific information, to make credit card payments, lodge government forms, etc.*

Additionally, for most of the above technologies, usage increased with employment size:

- **Government organisations with 1–99 employees:**
  - 15% had bar-coding/scanning systems;
  - 2% had IVR;
  - 19% had video conferencing/teleconferencing;
  - 6% had EFTPOS; and
  - 6% had kiosk facilities.
- **Government organisations with 1,000 or more employees:**
  - 84% had bar-coding/scanning systems;
  - 28% had IVR;
  - 61% had video conferencing / teleconferencing;
  - 24% had EFTPOS; and
  - 19% had kiosk facilities.

2.5 International Comparison

The data presented in the NOIE Index (Table 2-1) ranks fourteen key countries across twenty-three statistical indicators relating to progress in the Information Economy, with each country receiving a final score for ranking purposes. For each country, the table presents:

- individual scores for each indicator;
- a total score calculated across all indicators;
- an average score, which is used to produce the final country ranking, calculated by taking the total number of points each country received and dividing by the number of indicators for which data is available; and
- a final ranking from 1 to 14 (14 being the lowest rank) (NOIE 2002).

Table 2-1: Fourteen Key Countries across Twenty-Three Statistical Indicators (2002)

REF NO.	14 KEY COUNTRIES													
	AUS	FRA	GER	HK	IRE	ITA	NOR	NZ	SING	S. KOR	SWE	TAI	UK	US
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1	97	90	97	99	84	93	**100**	93	98	99	**100**	98	94	94
2	11	5	9	13	8	1	20	8	14	1	6	25	7	**29**
3	64	46	51	75	60	65	69	68	59	66	68	69	60	53
4	67	35	47	62	44	42	60	62	64	**70**	65	58	47	65
5	52	22	36	58	46	34	52	54	55	56	**58**	51	47	54
6	5	13	8	52	1	4	5	5	25	**87**	12	38	4	19
7	54	20	36	59	35	34	57	53	59	62	**65**	55	42	64
8	72	48	54	69	66	46	77	75	65	71	**82**	64	61	76
9	92	42	64	89	78	54	100	94	84	81	**107**	76	77	101
10	64	73	65	41	46	60	64	64	68	66	**78**	52	43	64
11*	**99**	91	89	97	96	89	95	96	97	95	95	98	91	97
12	**88**	63	74	79	74	73	75	82	75	73	80	77	77	
13	**100**	4	5	7	53	7	7	30	8	1	8	1	13	75
14	36	21	16	15	29	6	14	36	31	2	20	4	26	**49**
15	56	40	47		32	52	37	63		53	41		39	**100**
16	20	40	39		46	22	67	20		12	**100**		41	41
17*	19.5	21.4	25	31.1	13.4	17.5	16.4	21.6	23.4	**45**	17.5	21	19	30.3
18*	64	61	81	35	47	36	74	62	47	67	90	42	73	**103**
19	24	18	32	22	3	5	55		18	10	71	18	43	**100**
20	37	13	23	27	20	10	33		37	27	53	43	30	**100**
21	25	21	30	25	5	19	**32**	16	23	13	18	5	8	21
22	50.7	40.1	40.6		46.9	37.8	36.5	36.8	43.4	33.4	29.4	52.5	47.1	**57**
23	83	73	75	75	73	67	81	70	79	70	80	72	81	**87**
Total	1280	900.5	1044	1030	1006	874	1227	1109	1073	1161	1344	1020	1070	1480
Score	55.7	39.15	45.4	51.5	43.8	38	53.3	52.8	51.1	50.5	58.4	48.55	46.5	67.3
Rank	**3**	**13**	**11**	**6**	**12**	**14**	**4**	**5**	**7**	**8**	**2**	**9**	**10**	**1**

Note:

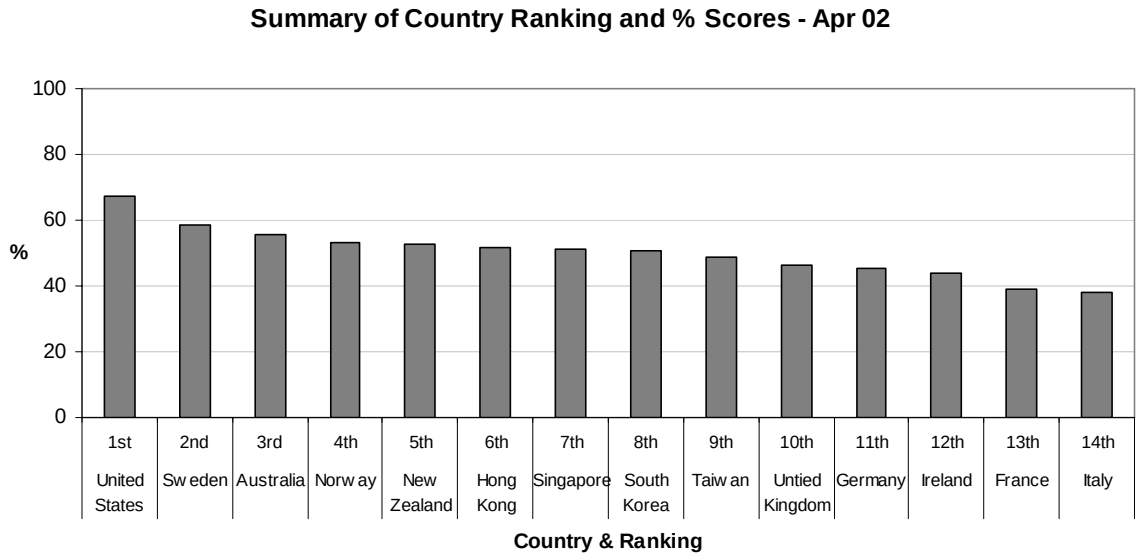
- **: Combined score*
- *Leading score (%) for each indicator in **bold** numbers.*

Key to Table 2-1 - Indicator Reference Numbers 1-23:

1. *%of households with a fixed telephone line*
2. *% of households with more than one telephone line*
3. *% of persons 16 years and over with use of a mobile phone*
4. *% of households which own / lease a PC*
5. *% of households online*
6. *Internet connection speeds*
7. *% of persons 2 years and over with Internet access via a home PC*
8. *% of persons 16 years and over with Internet access from any location*
9. *% of persons 16 years and over with Internet access at home or work*
10. *% of persons 16 years and over with Internet access using the Internet*
11. *% of persons 16 years and over with Internet access by gender*
12. *% of persons 16 years and over with Internet access by age group*
13. *Number of persons 16 years and over with Internet access per ISP*
14. *Number of secure servers / 100,000 persons 16 years and over with Internet access*
15. *Price of 40 hours of Internet use at peak times*
16. *Charges for a basket of national leased lines of 2 megabits per second*
17. *Average number of Internet sessions and hours online per month*
18. *% of persons 16 years and over purchasing online*
19. *B2C as a % of GDP*
20. *B2B as a % of GDP*
21. *Peak penetration of online government services*
22. *E-government rankings*
23. *E-business readiness rankings*

According to (NOIE 2002), most of the countries selected for benchmarking against Australia (Table 2-1) have confirmed high levels of adoption and use of technologies (e.g.: Internet), with increased levels of economic and social activity occurring online. Yet, there is still significant room for improvement for the majority of countries benchmarked, with large sections of their respective populations remaining outside the Information Economy – i.e.: either having access to the Internet and not using this resource, or not having the opportunity to use the Internet due to lack of access. Figure 2-12 provides a summary of ranking (refer last row of Table 2-1):

Figure 2-12: Summary of Country Ranking and % Scores – April 2002



Referring to Figure 2-12:

- The United States (US) is ranked the highest in the Index with consistent performances across the range of Index indicators.
- The US, Scandinavian countries, Australia, New Zealand and the smaller countries of South East and East Asia are in a strong position to take advantage of the potential benefits of the emerging global Information Economy.
- The US (67.3), Sweden (58.4), Australia (55.7) and Norway (53.3) occupy the top four positions in the NOIE Index (NOIE 2002).
- Other countries recording a high Index score included:
  - New Zealand (52.8);
  - Hong Kong (51.5);
  - Singapore (51.1); and
  - South Korea (50.5) points respectively.
- The remaining two positions in the top ten were taken by:
  - Taiwan (48.5) and UK (46.5).
  - The UK was followed closely by Germany on 45.4 points and Ireland on 43.8 points, while
  - France and Italy occupied the last two positions with significantly lower scores, 39.15 and 38 points respectively.

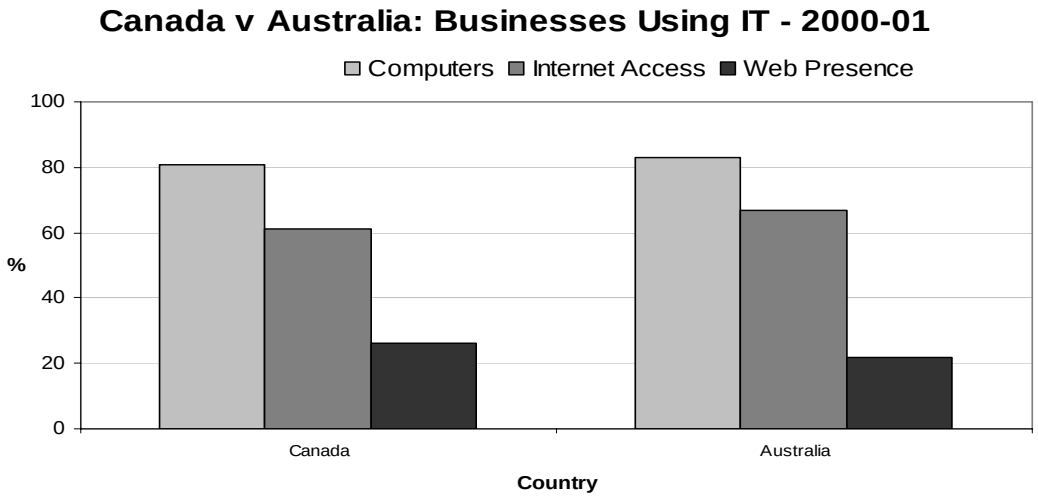
In summary and referring to Figure 2-12, Australia's overall score of 55.7 places it 3rd and in close proximity to the Index leaders. Therefore, according to (NOIE 2002), Australians are major adopters of Information Economy enabling technologies (e.g.: Internet, computers, and mobile telephones), and increasingly use the Internet for a wide range of activities associated with their day-to-day lives.

According to (ABS 2002), the National Statistical Offices are making reasonable progress in their efforts to collect comparable international data on IT use and e-commerce. However, due to differences in the 'scope' and 'content' of surveys covering these topics, Australian statistics can only be compared with those from a relatively small number of other countries. The following sections present a summary of these international comparisons, whilst the adjusted 'scope' of the Australian survey (for the UK and Nordic comparisons) can be viewed in Appendix A.

2.5.1 Australia v Canada - Private Sector Businesses & Internet Commerce

Referring to Figure 2-13, there is little difference between Australia and Canada's uptake of computers, Internet or web sites / home pages. This, according to (ABS 2002), may be attributable to the later reference period for the Australian survey (2000 v 2001). Australia is slightly ahead on computer use and Internet access, but trails behind Canada (slightly) with regard to web site use by businesses.

Figure 2-13: Canada v Australia: Businesses Using IT – 2000-01

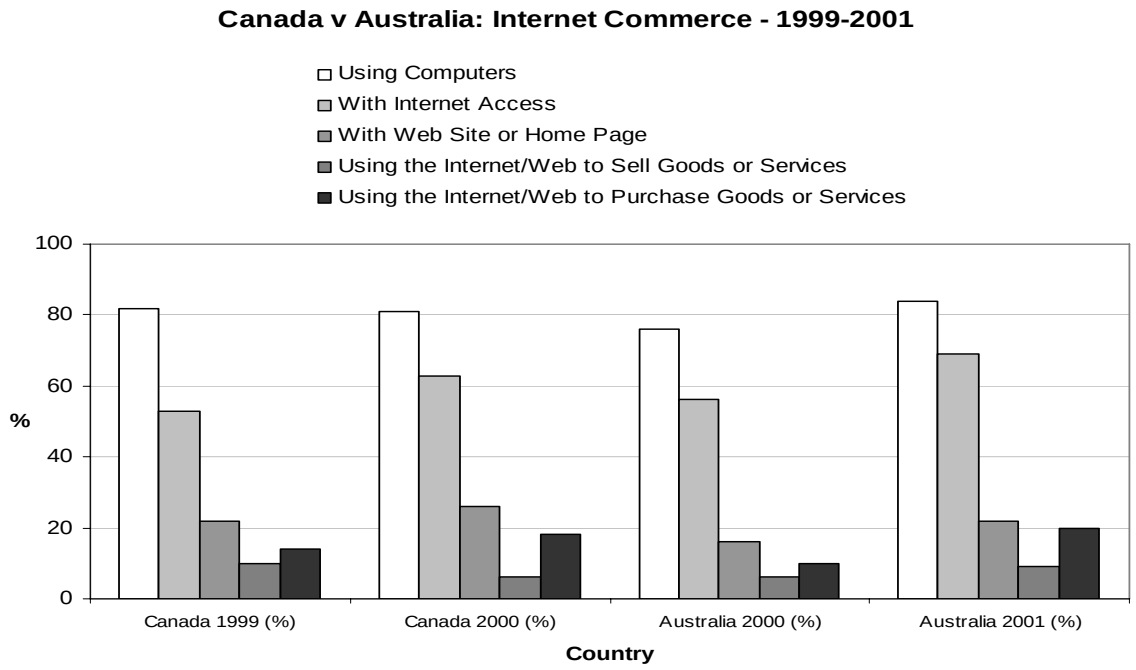


Note:
Canadian Data is for 2000 and Australian data for 2000-01.

An Australian-Canadian comparison of Internet commerce is shown in Figure 2-14 (ABS 2002):

- Whilst the proportion of businesses using the Internet / Web (to sell goods or services) has increased for Australia, it has decreased for Canada (from 10% to 6%) – decrease caused by a concentration of Internet selling into fewer and larger businesses.
- For both countries, the proportion of businesses using the Internet/Web for purchasing has increased (more for Australia than for Canada).
- The value of Internet sales (absolute terms and proportion of income) has increased significantly for both countries, with Australia leading on both indicators.

Figure 2-14: Canada v Australia: Internet Commerce – 1999-2001

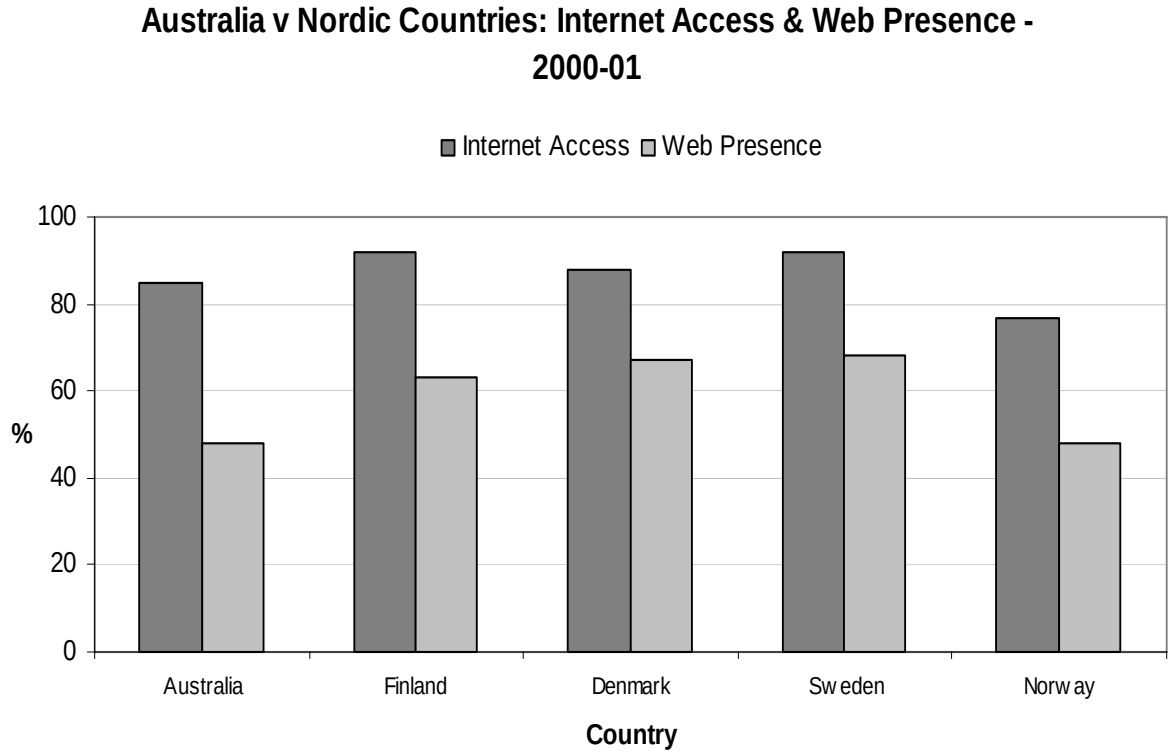


Note:
Canadian data is for 1999-2000 and Australian data for 2000-2001

2.5.2 Australia v Nordic countries

In terms of business Internet access, Australia compares reasonably well against the Nordic countries, but less for Web presence (Figure 2-15) (ABS 2002):

Figure 2-15: Australia v Nordic Countries: Internet Access & Web Presence - 2000-01



Note:

- *Scope of the Australian survey was adjusted to match the Nordic surveys*
- *Australia Data - 30 June 2001*
- *Nordic Country Data – end 2000*

2.5.3 Australia v the United Kingdom (UK)

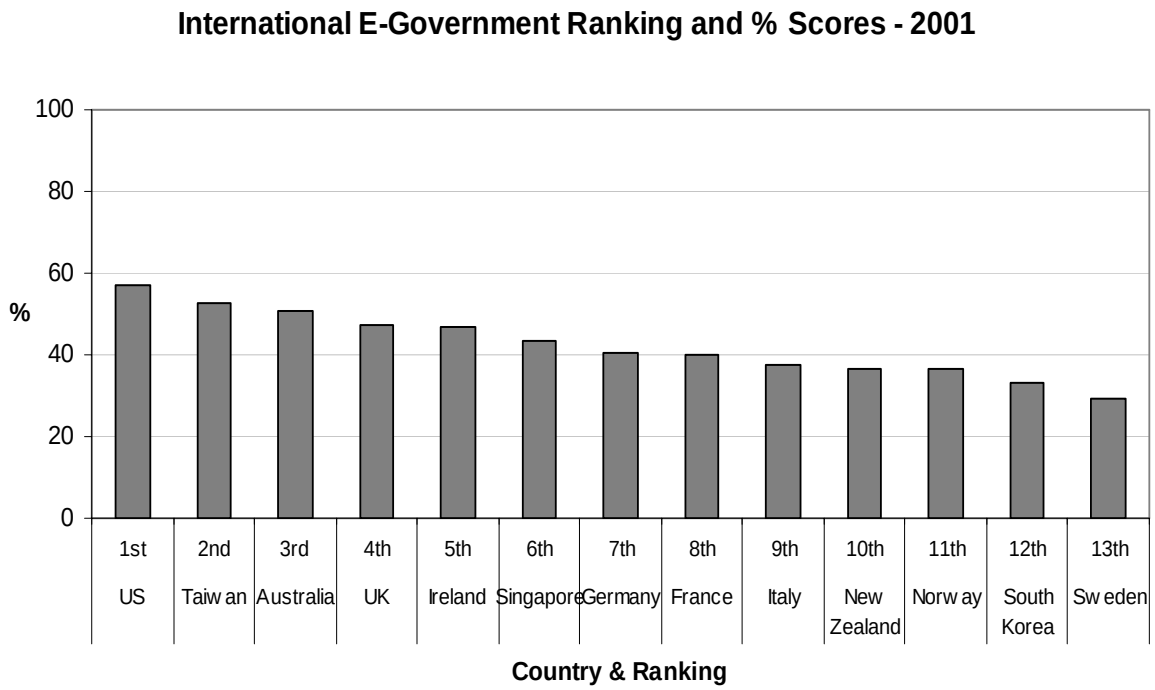
When comparing the value of Internet commerce in the UK against Australia, the UK is more advanced than Australia in respect of Internet sales (ABS 2002):

- For the UK, the total value of sales made (using the Internet) for the calendar year 2000 was £13 billion (excluding the Finance Sector), representing 0.94% of all sales made by businesses.
- The comparable Australian figures were AUS$6.4 billion and 0.75% respectively.

2.5.4 E-Government Rankings

Arguably Figure 2-16 illustrates that Australia performed well in the 'E-Government Rankings' survey, which was produced by the 'World Markets Research Centre' and results reported in (NOIE 2002).

Figure 2-16: International E-Government Rankings and % Scores - 2001



Note:
Data for Hong Kong for this indicator was not available.

In summary (referring to Figure 2-16), Australia was ranked 3rd behind the US and Taiwan for the proportion of its government web sites - in compliance with the assessment criteria based on the scope of information provided on agency web sites - i.e.: clarity of the site, privacy and security policy, etc. In Australia, 50.7% of all the Federal Government agency web sites examined in (NOIE 2002), conformed to all assessment criteria - compared to 57.2% of sites in the US (1st) and 52.5% of sites in Taiwan (2nd).

3 INDUSTRY'S NEED FOR TECHNOLOGICAL INNOVATION & CHANGE

3.1 Forces of Change

Change is 'the *only thing constant in our world today'.* Many information systems (IS) and information technology (IT) managers of firms are 'seduced' by new technologies, 'blinding' them from being focused on the real reasons and need for change (Hee H. 1998). The construction industry would be wrong by saying that the following forces of change for construction will not affect it: (Flanagan R. 1998)

- technology, knowledge and skills;
- globalisation;
- demographic trends;
- pace for economic change;
- more competition;
- new employment patterns and organisational structures;
- changing clients; and
- growing importance of environmental issues and pressure groups.

3.2 Types of Innovation

Even though the industry has always been innovative, it can sometimes be 'too innovative', where firms and practitioners demonstrate 'directionless inventiveness' in searching for ways to overcome problems. This results in one of three types of innovation (Gann D. 1997):

- unstructured innovation: where benefits of improved quality and speed, and reduced costs are not necessarily the goal;
- incremental innovation: resulting in major changes to overall performance due to small changes made by one firm causing inefficient practice further within the construction process as a whole; or
- radical innovation: usually accompanied by major structural change, new forms of competition and industrial upheaval, resulting in benefits to clients and innovative firms.

3.3 Competitive Re-engineering

It is suggested that the Australian construction industry, if it is to remain competitive in the global market, needs to move from functional-based tasks towards a more 'holistic view' of their organisations and procurement of projects (Love P.E.D. 1996). This is achievable through process and organisational innovation (re-engineering) and through creative applications of IT. Love describes the use of IT in the construction industry as an 'enabler' of process re-engineering, with capabilities including:

- Information storage – the ability to store information in a form that permits the user or a computer application to retrieve the information when needed (for example, databases).
- Information retrieval – the ability to access information and retrieve it from storage (for example, databases).
- Information sharing – the ability of a number of users or applications to simultaneously access and view information (for example, integrated databases and network systems).
- Information transfer – the ability to connect computers and computer related devices to enable the transfer of information among computers, applications and users (for example, networking CAD).

- Information forwarding – the ability to automatically forward information from one application or user to another user (e.g. electronic data exchange).

3.4 Performance and Cost

Innovation in information and telecommunications industries has resulted in rapid performance improvements and 'cheapening' of equipment. Yet in contrast, much slower relative price increase has been achieved in buildings, infrastructure, and often little improvement in functionality. The need for improved performances and technological innovation in construction therefore stems from (Gann D. 1997):

- buildings and structures becoming more costly to purchase and operate, relative to other industrial products – e.g.: lower rates of productivity growth in construction compared with manufacturing have caused a relative increase in construction costs; and
- client expectations being formed by comparisons with perceived improvements in cost and performance of other products and services (not just from construction firms).
- larger clients demanding lower prices, which in turn lead to long-term problems of profitability in construction firms.

3.5 Organisational Integration

The industry's efficiency, responsiveness and capability to innovate depend on the type of skills employed, the relationships with other firms embodying technical expertise and transfer of technical expertise between '*temporary coalitions*' of firms and their customers in supply and demand chains. (Gann D. 1997) identifies two levels of innovative activity:

- Small *ad hoc* changes: changes and adaptation to material and components made by supply and construction organisations that are crucial to getting the project finished.
- Major changes: changes to materials, components and equipment (from planned R&D) and generally leading away from traditional practices and towards more engineered and assembly methods.

The above temporary integration of construction industry organisations can be described as an 'environment' consisting of five main sectors: technology, supplier, regulatory, competitor, and customer. This environment (individually and as a group) and its relationship with / influence on the organisation, determine the level of profitability, growth, performance and technological innovation (Toole T.M. 1998).

4 E-BUSINESS / COMMERCE

4.1 Categories

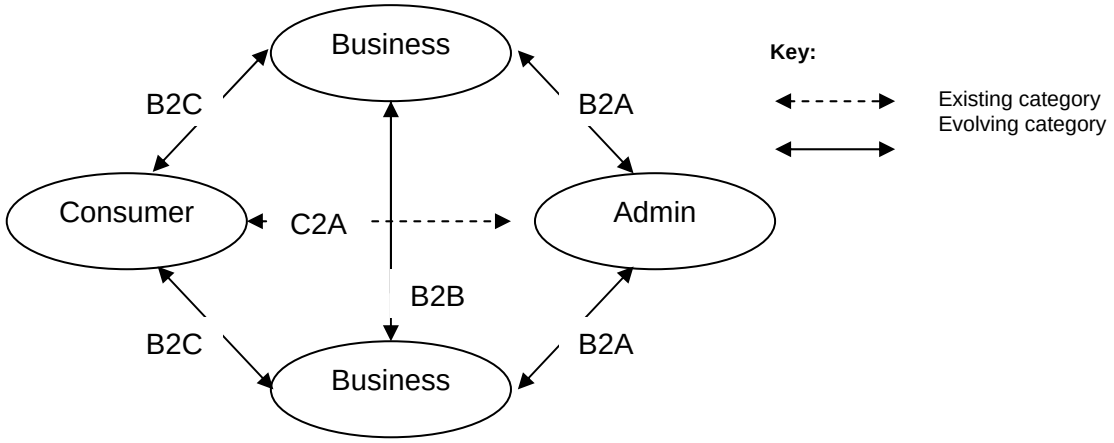
The Internet has debatably revolutionised the way in which information is stored, exchanged and viewed, opening new avenues for businesses, which were only a decade ago almost inconceivable. This growing interest in the conduct of business transactions by electronic means through the Internet and/or dedicated networks; is often referred to as ecommerce (Anumba C.J. and Ruikar K. 2002). e-Business solutions enable local and international businesses to get online quickly and effectively over the Internet (DCITA 1998) and (IIB 2002). Examples of Internet commerce include:

- Electronic Data Interchange (EDI);
- Electronic Funds Transfer;
- Shared databases; and
- Electronic mail.

Four main e-Commerce categories include (Figure 4-1): (Anumba C.J. and Ruikar K. 2002) and (Ecommerce 2002)

- **Business-to-Business (B2B):** an electronic means of carrying out business transactions between two or more businesses, incorporating everything from manufacturing to service providers – i.e.: electronic orders, receiving electronic invoices and making payments electronically.
- **Business-to-Consumer (B2C):** similar in concept to the traditional method of retailing. The main difference being the medium used to carry out business – i.e.: Internet.
- **Business-to-Administration (B2A):** covers all the transactions that are carried out between businesses and government bodies (e.g. details of government policies, initiatives and other information).
- **Consumer-to-Administration (C2A):** relatively new – e.g.: through various UK governments initiatives such as:
  - UK Online - a joint venture of the UK government with the industry, voluntary sector, trades unions, and consumer groups to facilitate Internet access to UK citizens. Facilities include e-Democracy, e-Voting, information about public services, e-Health, and publishing of advantages such as paperless offices, faster communications and reduced costs compared to traditional methods, etc.

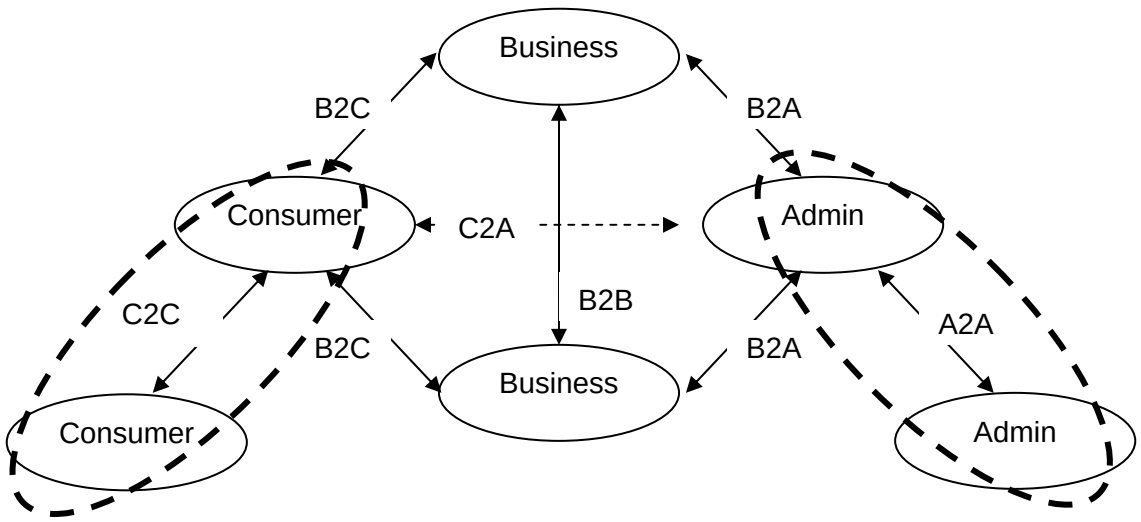
Figure 4-1: e-Commerce Categories



A further two e-Commerce categories are identified shown in Figure 4-2 (Anumba C.J. and Ruikar K. 2002):

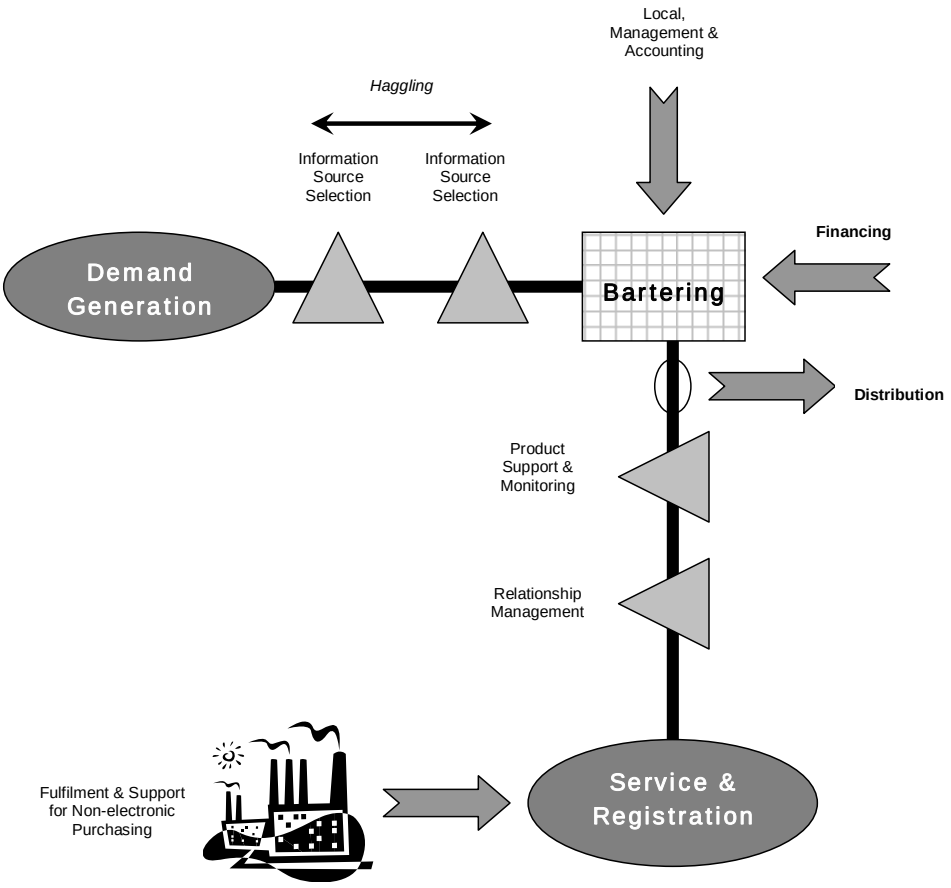
- **Consumer-to-Consumer (C2C)**: even though no financial transaction takes place, the exchange of value is still deemed as an internet-based economic activity (e.g.: e-Auctions); and
- **Administration-to Administration (A2A)**: where future governments from different countries exchange documents and data or conduct business transactions electronically.

Figure 4-2: Additional e-Commerce Categories



e-Commerce covers a broad area, conducted via a host of tools, instruments and systems, including telephone, fax machine, electronic payment and money transfer systems, electronic data interchange (EDI) and the Internet. During the last decade, B2B e-Commerce has grown rapidly, mainly because companies needed the related cost-savings and efficiencies to stay competitive. The e-Commerce Model (Figure 4-3) illustrates the elements of the contemporary electronic commerce process (DIST 1998).

Figure 4-3: eCommerce Process Model



4.2 In Construction

Current and future ICT developments (particularly in e-Commerce) and its applicability and uptake within the construction industry, is causing virtually every business sector to shift away from or 'radically alter' traditional, tried and tested methods of communications (Anumba C.J. and Ruikar K. 2002). Although the industry is identified as embracing / making use of various Internet tools and systems (in several different ways), it is still slow (overall) in e-Commerce adoption when compared to other engineering sectors (such as the automotive or aerospace industry). The restricted uptake is mainly due to the:

- fragmented nature of the industry; and
- one-off nature of its projects.

Today, many organisations offering e-Commerce services and solutions are increasingly taking advantage of the current inefficient methods of communication and data exchange within the construction industry. This positive infiltration is made possible through the use of Web-based solutions for communication and project management, resulting in increased efficiencies in project communications, leading to overall time and cost savings (Anumba C.J. and Ruikar K. 2002).

5 KEY CASE STUDIES

As illustrated throughout this report, there are numerous examples of ICT implementation as well as research and development (R&D) activities within the Australian and international construction industry. Arguably, current levels of ICT adoption within the construction industry vary from country to country.

Presented in Sections 6.1 through 6.14 are fourteen (14) key case study summaries of such ICT implementation, adoption and R&D activities within the industry. The case studies presented are not exhaustive - only covering a small yet relevant sample of current research activities within Australia, New Zealand, UK, USA, Canada and South Korea.

5.1 Case Study 1: Technology – Enhanced Project Management - USA

(Zipf P.J. 2000)

The engineering department of Port Authority of New York and New Jersey set out to determine ways to produce more work with fewer staff using electronic communication tools. ICTs identified included:

- local area networks (LANs);
- wide area networks (WANs);
- electronic communication;
- integrated project management systems;
- geographic information systems (GIS);
- electronic document management systems;
- enterprise wide database systems; and
- email.

As distance often separate project team members and organisations, and effective communication are considered important in improving the quality on any project, the above technologies are said to:

- increase the ability to ‘change direction’ at any stage of a project;
- make it possible for ‘timely’ information to be provided to project managers thereby ensuring effective management; and
- need to become part of any projects daily communication routing.

The engineering department then established a pilot project to store contract drawings and files electronically (storage, retrieval and transmission of contract documents), with three main goals:

- make documents available on a compact disk for easy distribution;
- create a project-oriented centralised CAD drawing storage system; and
- provide electronic storage of contract documents.

To achieve these goals, the department dealt with a variety of issues, including:

- **Electronic signatures and contract drawings:**
  Recognising that the electronic transmission of engineering documentation is increasingly becoming common in the industry, the electronic approval software was identified as being relatively new and the standards of reliability, security and usability have not yet been established and proven for these systems.
- **Format of drawing distribution:**

Portable documentation format (PDF) was identified as fast becoming the standard for publication and distribution of documents via CD-ROM and the Web, due to advantages including:

- ability to convert computer-aided designs, documents, drawings, images, etc into a single format;
- free download of software for reading PDF is available on the Web;
- ability to read, print or plot PDF documents without modifying or changing file extensions; and
- all files are in one common format for distribution.

Furthermore, to handle the extensive storage and retrieval of engineering documentation and specifications, it is recommended that an electronic document management system (EDMS) be implemented, which would provide a number of benefits, including:

- simplified PC-based tracking and maintenance of documents and specifications;
- use of 'version control' to keep track of different versions;
- documents can be submitted electronically for review and final distribution;
- ability to electronically file and record documents, drawings and specifications in a centralised location; and
- immediate access by staff.

Finally, the engineering department identified the following GIS applications:

- information related traffic engineering – i.e.: traffic signs, signals and traffic volume counts;
- development of an authority-wide accident reporting and analysis system;
- traffic sign management system - to link sign requests through production and installation at facilities;
- centralised environmental and material testing results database - allowing agency wide access; and
- asset management.

5.2 Case Study 2: Web-based Decision Support Systems - USA

(Molenaar K.R. and Songer A.D. 2001)

Due to current Web-based technologies providing appropriate means for large scale implementation, and continued development of decision support systems (DSS) for the architectural, engineering and construction community, this paper reports on the application and potential for a Web-based DSS (Design / Building Selector – DBS) in civil engineering. DSS is defined as: '*computer programs that aid users in a problem solving or decision making environment'* and '*not being a direct solution to the user - requiring user input to add value to the system output - in order to reach a decision'.* Implementing a Web-based DSS has the following potential benefits:

- Accessibility: while traditional support systems require software or installation on individual workstations or computers, Web-based DSS are available to any person with Internet access;
- Efficient distribution: elimination of separate installation costs and licensing issues;
- Effective administration: adjustment and additions to the DSS or its database are faster than traditional upgrades, where controlling the system from a central location provides real-time change management; and
- Cross platform flexibility: eliminates the need to distinguish between various platforms.

The DBS program investigated on this project is a Web-based DSS that assists the public sector owners in the selection of projects that are appropriate for design / build:

- providing an accessible, formalised and repeatable method for benchmarking design / build projects;

- providing reference and advisory information - assisting owner organisations (unfamiliar with design / build) in choosing the most appropriate projects; and
- 'smoothing' the learning curve for public sector design / build project delivery.

The paper concludes the largest hurdle that exists in implementing a dynamic version of the DBS, is the validation of new project data and advisory information (expected to be addressed in future versions). A demonstration and tutorial of the DBS is available at http://www.colorado.edu/engineering/civil/db/.

5.3 Case Study 3: Online Remote Construction Management - Australia

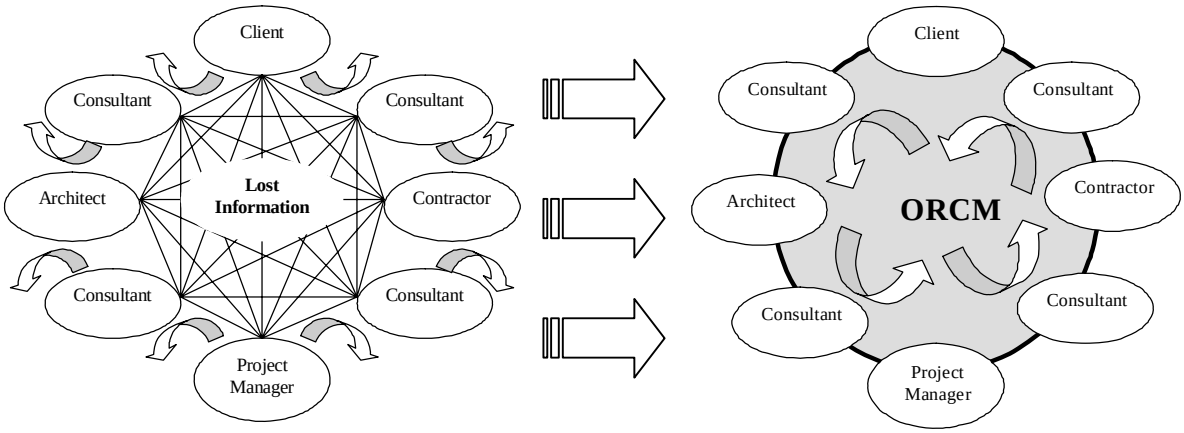
(Kajewski S.L., Weippert A. et al. 2002)

The Online Remote Construction Management (ORCM) project - a collaborative research project funded and supported by a number of Australian (Queensland) industry, government and university based project partners - commenced in July 1999 aiming (in general) to develop, trial and/or evaluate ICT tools and/or ICPM systems on four remote located building and / or civil construction projects over a two-year period. Ultimately allowing collaborative design and construction to be undertaken between members of a geographically dispersed project consortium, achieved by demonstrating leadership in identifying and implementing appropriate and innovative ICT solutions that will ultimately:

- improve resource management,
- support and integrate total project life cycle considerations;
- increase efficiencies; and
- reduce overall cost and improve project outcomes.

Additionally, project communication and information 'leaks', losses or misplacements would be kept to an absolute minimum where all members of the project consortia would be in possession of the most up-to-date and accurate project information (Figure 5-1).

Figure 5-1: Traditional v ORCM Information & Communication System



Briefly, the main objective of the ORCM research project included (but not limited to) identifying, examining and evaluating:

- perceived communication practices of contractors with other project participants;
- extent and occurrence of requests for information (RFI) and site instructions (SI) (in particular);

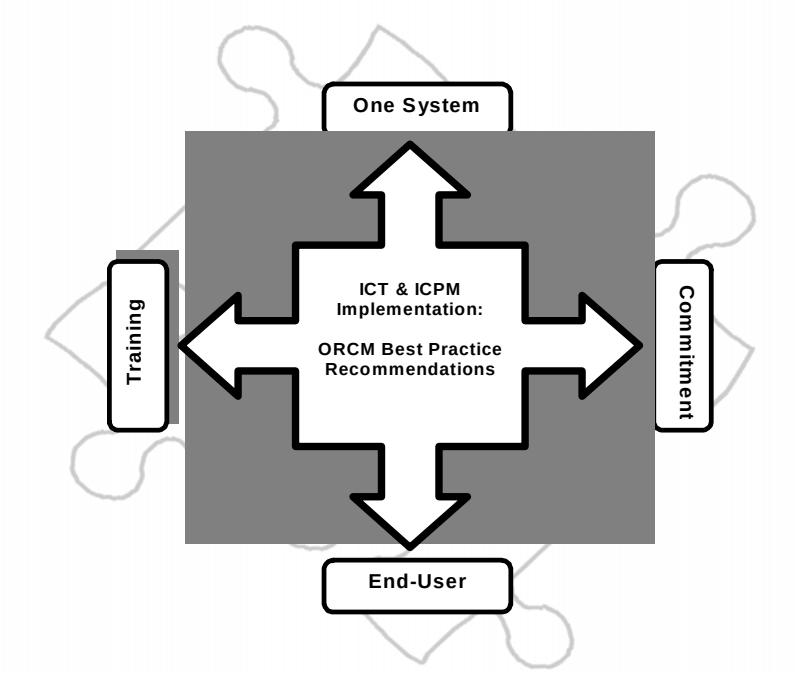
- time implications of inappropriate, insufficient, conflicting or questionable information;
- barriers that inhibit the flow of information; and
- impact of advanced ICT had on the information and communication flow process throughout a project.

To ensure ORCM aims and objectives were achieved, research activities concentrated on collecting and classifying the communication data originating from, to and/or through the stakeholders (clients, architects, engineers, consultants, subcontractors, suppliers, etc.) of four remote located building / civil ORCM Case Study (CS) projects. These were then compared (benchmarked) against the communication data of four traditionally delivered (paper-based) benchmark projects (BM) - i.e.: building / civil construction projects of similar size, value, location (remoteness) etc, to that of the four CS projects. With this in mind, Queensland Department of Main Roads (QDMR); Queensland Department of Public Works (QDPW); and two private industry partners:

- assisted ORCM researchers identify four remote CS and BM projects and
- provided / authorised access to organisation head / regional offices and project team members / information / data / etc.

ORCM researchers, (through: implementing two ORCM surveys; carrying out formal and informal interviews; and undertaking of extensive benchmarking and cost benefit analysis activities) identified the following 'Best Practice Recommendations' that would help ensure successful implementation of information and communication technology (ICT) tools and Internet-based construction project management (ICPM) communication systems on geographically dispersed (remote) civil and building construction projects (Figure 5-2):

Figure 5-2: ORCM Best Practice Recommendations



Key to Figure 5-2:

- **One System:** One Project – One Team – One System: Project participants want to learn to use only one ICT tool or ICPM system for ease of understanding its capabilities, etc:
  - System Compatibility: The capabilities and functionality have to be compatible with most other ICT products and ICPM systems used in the industry – potentially saving overall implementation time, cost, labour, errors, etc. Application of an ICPM system must not be a 'black box' of information processing.

- Ease of Data Entry: Commonality of an ICPM system's access features and ease of data entry is most important. Free access to downloadable and compatible readers and 'plug-ins' for common access to data must be provided by ICT tool and ICPM communication system developers. Either there is one industry/client wide system or there is a common user interface.
- Fully resourced Implementation: Trialling an ICPM system (that has not had much exposure to industry participants) should be treated as a 'special case' with proper backing, support and experience from developers, implementers and researchers – i.e.: a new ICT system should be fully resourced to ensure that all aspects are covered during the early stages of its implementation (e.g.: reliability, capability, etc. of essential project communications).

- **End User – Prime Focus:** The end user is a key factor in gaining advantage from an ICPM system. Taking only the type or potential advantages, capabilities, etc of a newly developed ICT tool or ICPM communication system into consideration is not enough during implementation. End user needs, expectations, requirements, recommendations, comments, etc must be a prime focus:
  - User v Quality and Accuracy: The quality and accuracy of any project related communication or information (electronic or paper based) is directly dependant on the user or creator of that piece of information or correspondence (with or without an ICT tool) - technology alone is not enough to guarantee improved quality and accuracy of project related communications.
  - Trust: Implementing a new ICT product or ICPM communication system must create a feeling of trust (reliability, relevance, need, etc.) for potential users.
  - Designed for the Construction Industry by the Construction Industry: Whilst developing a new ICT product or ICPM system, the end users must be involved from the beginning to ensure a greater chance of successful ICT uptake.
- **Training:** Training in the use of a new ICPM system is essential. This includes continuous access to a telephonic or online 'Help Desk', regular onsite demonstrations and 'refresher' training sessions to ensure continuous learning and understanding of what the system is capable of, as well as recognising and accepting its limitations.
- **Commitment:** *All project participants and stakeholders need to be fully committed to using the new ICT tool or ICPM communication system, with 'buy in' and collaboration at the highest level within participating companies, thereby reassuring and guaranteeing potential users of a 'corporate commitment'.*
  - IT Driver: Every project should have a 'driver' of ICT uptake (Superintendent or equivalent), encouraging, supporting and monitoring its application and its use throughout all phases of a project.
  - Legal Issues: ORCM 'Best Practice Recommendations' are susceptible to the current legal status regarding electronic transmissions, the use of electronic signatures, etc. Commitment by both government and industry sectors is required to help develop more innovative strategies to build a stronger and more competitive construction industry. ORCM Committee Members and their organisations have sought legal advice regarding the use of electronic communications on both public and private sector projects.

5.4 Case Study 4: Web-based Construction Document Processing via Malleable Frame - USA

(Zhu Y., Issa R.R.A. et al. 2001)

A pilot study, to determine whether processing a 'malleable' frame construction document is more efficient than processing a standard document, is undertaken by providing an alternative to achieve construction data interoperability via the web. The paper identifies three types of Web-based applications that exist in the construction industry today:

- free-based project management services;
- build-it-yourself solutions; and

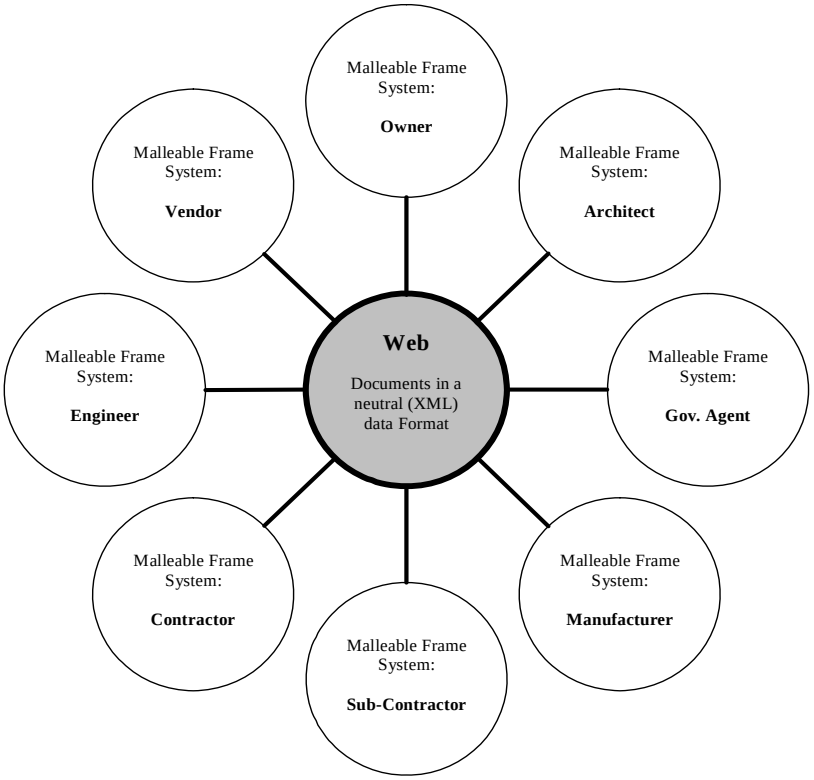
- Web-enabled software.

All three applications have the same objective - to integrate Web-based technology into construction projects and to ensure increased efficiency in data exchange without geographic boundaries. Unfortunately, current Web-based approaches do not effectively solve the problem of data interoperability and the automation of document processing is not possible due to different software vendors using different data formats.

The outcome of this research is a Web-based 'malleable' frame approach, concentrating on two issues (Figure 5-3):

- **Construction documents**: documents are an integral part of any project (acting as 'bridges for communication' between project participant), and should be an integral part of the whole integration strategy; and
- **Front-end integration**: using 'system-independent' and 'vendor-independent' neutral information models at the front end (input / output level), allows construction professionals to access a more integrated computing environment over the Web.

Figure 5-3: Web-Based Front-End Integration



Note:
Malleable is defined here as '*a dynamic document template*' which '*defines the neutral data format of a particular type of document*' – i.e.: in the Web environment, such a neutral format can be designed by using eXtended Markup Language (XML) technology.

The paper concludes by stating the development and use of such a malleable system does not actually reduce processing time, yet proven to complete a task (involving the processing of construction documents) significantly faster than by using a system without malleability. However, the study was inconclusive as to whether the malleable frame system is better than a standard system, suggesting further exploration and testing of features such as:

- information type needed to process a particular document; and
- Mechanism of establishing a shared classification system at the project set-up phase.

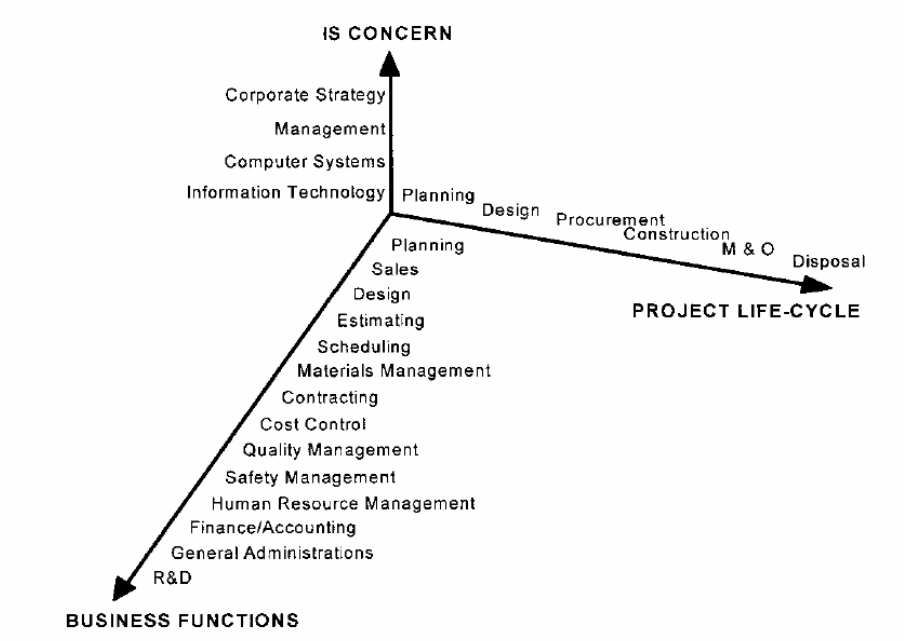
5.5 Case Study 5: Planning for Computer Integrated Construction - South Korea

(Jung Y. and Gibson E.G. 1999)

Computer integrated Construction (CIC) has evolved to maximise the integrated utilisation of information systems throughout a projects lifecycle and across different business sectors. Complicating CIC solutions are the 'dynamics of business requirements and technology development – i.e.: it is difficult to design systems for the industry, based on the current technology, resources, needs and benefits. Researchers therefore propose a planning methodology that incorporates comprehensive issues for 'real world' ICT implementation, where managerial issues are stressed throughout the planning process - making it more viable and efficient. CIC is redefined as '*the integration of corporate strategy, management computer systems and IT throughout the project life-cycle and across different business sectors*', from which a framework was developed, consisting of three variables (Figure 5-4):

- Project life cycle;
- Business function; and
- Information system (IS) concern.

Figure 5-4: Proposed CIC Framework



Extract from (Jung Y. and Gibson E.G. 1999)

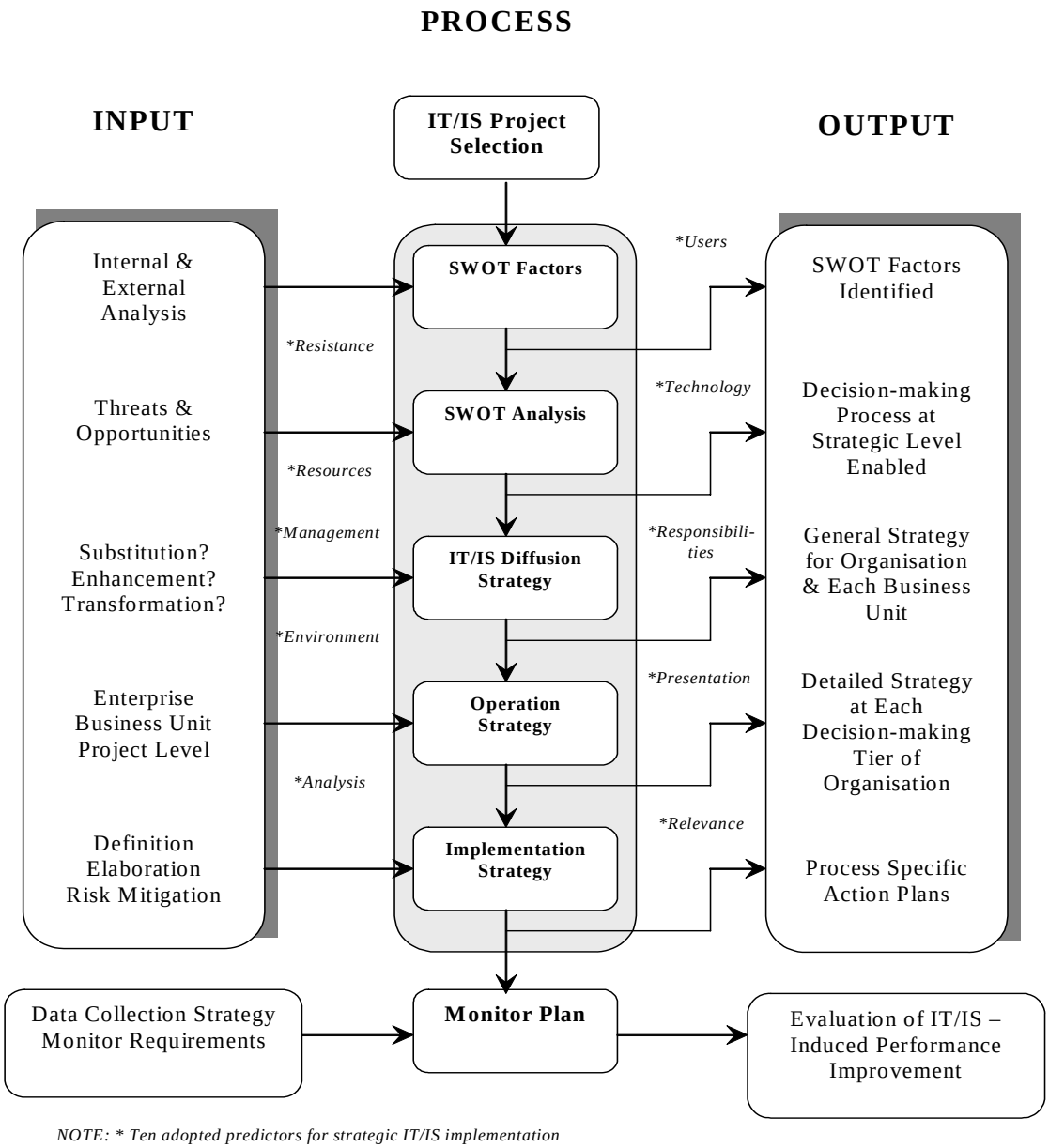
The paper concludes the CIC framework and planning methodology applied to a 'real-world' case study (large Korean construction firm) identified 'managerial issues' are universally critical in successfully implementing CIC, and applicable to any organisation in the construction industry, including: owners, construction managers, designers, and contractors (regardless of their size and discipline). Further stating that an overall strategy should be formulated to make its implementation within the industry more viable and efficient – i.e.: the industry requires a better planning capacity, which shares functional understanding, business-specific implications and economics.

5.6 Case Study 6: Strategic Implementation of IT/IS Projects in Construction: a Case Study - Australia

(Stewart R.A., Mohamed S. et al. 2002)

In order to facilitate ICT implementation and to encourage ICT uptake within construction organisations, the paper examines the implementation of a Project Management Information System (PMIS) on a case study project (to electronically manage the supply and construction of a multi-million dollar telecommunications infrastructure project). Additionally, researchers attempt to further develop a previous framework (Case Study 5: Figure 5-4). As a result, researchers tested, trialled and evaluated the newly developed 'Strategic IT / IS Implementation Framework' based on critical assessment of market opportunities and threats, as well as organisational strengths and weaknesses (Figure 5-5).

Figure 5-5: Strategic IT/IS Implementation Framework for Construction Organisations



*NOTE: * Ten adopted predictors for strategic IT/IS implementation*

Key to Figure 5-5:

- **Step 1 - SWOT Factors:** the strengths, weaknesses, opportunities and threats (SWOT) factors are identified by incorporating the values of the corporate management of the construction organisation (objectives, perceptions, beliefs, challenges, etc) whilst undertaking an internal (*environment in which the organisation is studying the potential opportunities and threats*) and external (*identifying the strengths and weaknesses of the organisation*) analysis.
- **Step 2 - SWOT Analysis**: SWOT factors identified in step 1 form the bases of their analysis. Incorporating an analytical hierarchy process (AHP) within a SWOT framework proves to add value to the analysis – providing decision-makers with quantitative information by methodically and systematically evaluating the SWOT factors and their (current or anticipated) intensities.
- **Step 3 – IT / IS Diffusion Strategy**: based on the outcomes / recommendations of the SWOT analysis (reviewed by all that have a vested interest) the following needs to be determined to ensure efficient use of the proposed system:
  - how the proposed project (implementing IT / IS) will benefit the organisation ('tie-in' with existing strategies and plans);
  - how organisational assets and processes will be effected by the new IT / IS project;
  - what changes (replacement, improvement, transformation, etc) will need to take place in order to take full advantage of the IT / IS project's capabilities; and
  - change proposal recommendations (including the logic behind those) for the organisation's structure, people (culture) and their tasks.
- **Step 4 – Operational Strategy**: step 3 outcomes / proposals are developed in more detail by considering the decision-making levels of the construction organisation – i.e.: project, business unit and enterprise 'tiers' and analysed in terms of:
  - Functions (business systems);
  - Hierarchies and responsibilities (organisational structure); and
  - Technical architecture required (network, software and hardware, security requirements, etc).
- **Step 5 – Implementation Strategy**: expressed as the most detailed component of the proposed IT / IS implementation framework – examining the risks, strategic importance and coordinated integration within the evolution / development / transformation of the construction organisation, suggesting the following three stages:
  - Definition of clearly defined action plans – i.e.: activities including:
    - inventory of actions for strategic IT / IS implementation;
    - study of implementation procedures (budget and organisational constraints, types of finance, etc.); and
    - action prioritisation (with reference to strategic importance).
  - Elaboration of action plan – i.e.: include:
    - study of each action element (objectives, work breakdown structure, expected results, etc);
    - time dimensions (constraints, precedence, etc);
    - cost estimation (purchase, development, maintenance costs, etc);
    - analysis of human resources (training, support, etc); and
    - IT / IS management and coordination structure.
  - Risk mitigation and coping strategies: envisaged risk factors or identified weaknesses can be limited by developing a coping strategy (pre-determined actions).
- **Step 6 – Monitoring Plan**: by simply developing an IT / IS strategic implementation plan will not guarantee a successful implementation. It is therefore suggested that careful consideration be given to the continual performance monitoring of the implementation throughout the lifecycle of the project.

The paper concludes by suggesting the introduction of the above proposed strategic IT / IS implementation framework will 'speed up' the rate at which changes in people, tasks and organisational structure will take place.

5.7 Case Study 7: Information Technology Planning Framework for Large-Scale Projects - USA

(Pena-Mora F., Vadhavkar S. et al. 1999)

New IT developments continue to have a significant impact on large-scale A/E/C projects. Furthermore, senior managers are faced with a number of difficult questions when it comes to maximising returns their IT investment:

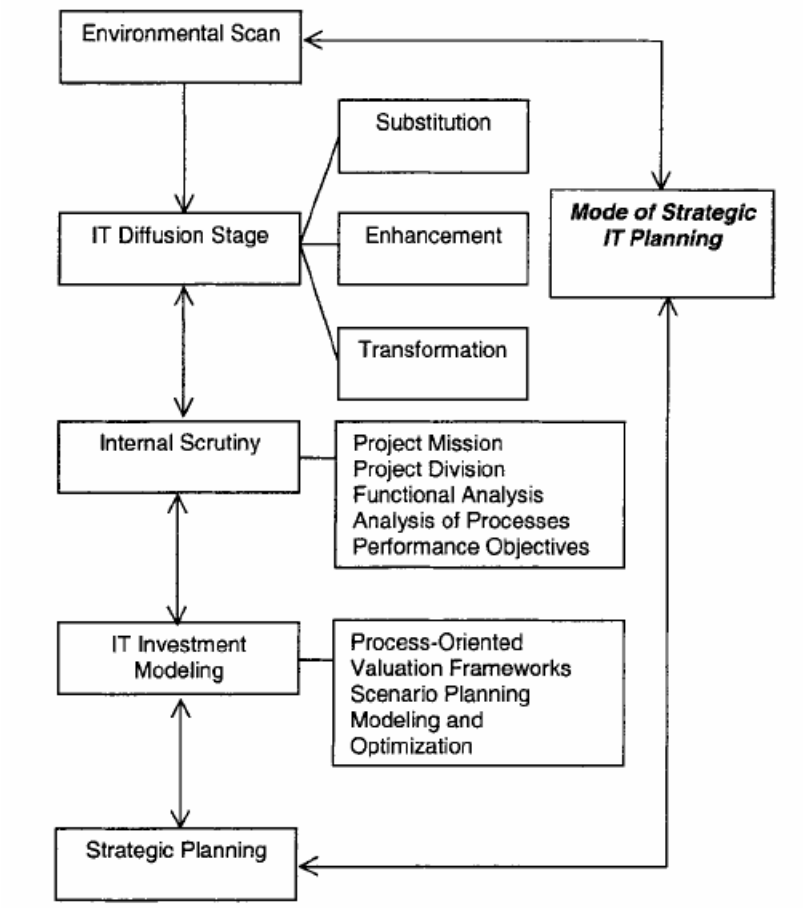
- How should IT investments be designed to ensure alignment with overall project objectives and strategy?
- How should these investments be prospectively justified?
- How can the value of these IT investments be measured over the project life span?
- How can the value of IT investments be quantified when the benefits accrue to more than one participating party (i.e., owners, contractors, and architects)?

Suggesting senior managers (of large-scale A/E/C projects) necessitate a ‘paradigm shift’ from the current ‘project management’ approach to an ‘investment management’ approach, which requires continuous valuation, monitoring and evaluation of investment programs over the project life span – i.e.: develop a sound methodology for planning and evaluating IT programs that will:

- allow greater accuracy in planning;
- provide data on the return of IT investment;
- reduce the risk associated with such a strategic investment;
- monitor the benefits of the IT investment over the entire project life cycle; and
- handle continuous infusion of IT investment over the entire project life cycle.

To address these issues, the paper proposes an ‘IT Strategic Planning Framework’ based on the above factors, prior research, and understanding of both internal businesses of the A/E/C project as well as the external dynamics of the overall economic environment (Figure 5-6).

Figure 5-6: IT Strategic Planning Framework



Extract from (Pena-Mora F., Vadhavkar S. et al. 1999)

The paper concludes by summarising the framework steps of Figure 5-6 that senior management would need to take into account (with some degree of iteration) when considering a new IT investment plan:

- **During the environmental scan of the project**: analyse the overall business goals of the A/E/C project and identify the economic environment in which the project operates.
- **For the IT diffusion step**: identify where in the IT diffusion phase the project and the participant organisations are.
- **From the internal scrutiny perspective**: determine the need for such IT investment depending on internal processes as well as the level of information that can be sustained on the project. Account for how the return on IT investment will be measured, right from the planning stage.
- **Lastly, in the IT investment modelling phase**: divide the sources of costs and benefits, (particularly for large-scale projects) in terms of training, personnel, models, methods, and processes developed among the different beneficiaries and organisations - i.e.: owners, contractors and designers. Account for value and depreciation in such benefit estimations and then compare the IT investment with competing interests (such as production investment) and relate it to 'intra-project' infrastructure - i.e.: number of contracting organisations.

5.8 Case Study 8: Simplified Spreadsheet Solutions: Subcontractor Information System (SIS) - Canada

(Hegazy T. and Ersahin T. 2001)

Without effectively managing business related information, few companies within the construction industry can survive in a competitive business environment. This paper presents a subcontractor information system (SIS) – i.e.: a spreadsheet-based information system for storing and utilising resources and projects related information - to support the estimating and project control functions of subcontractors and small / medium-size contractors.

SIS was developed using simple and powerful data management features of spreadsheets, providing 'transparency' for quick what-if analysis and designed to deal with information related to:

- project-independent recourses data;
- methods of construction – considering the impact of overtime strategy on time and cost;
- detailed project estimate – considering:
  - work breakdown structure (WBS);
  - alternate methods of construction; and
  - plan v actual performance.
- report generator on both the individual project and multi-project levels.

The paper concludes the proposed SIS is suitable for contractors who have a specific work domain and who do not want / can purchase large and costly databases. SIS benefits include:

- simplified implementation;
- ease of use;
- customary to many practitioners; and
- includes powerful capabilities that can satisfy the need of many users.

5.9 Case Study 9: Project-Specific Web Sites: Friend or Foe? - UK

(Thorpe T. and Mead S. 2001)

The industry's current information network is based on project or communication 'push' – i.e.: information moving successively to and from each member of the project team. The paper suggests the implementation of alternative communication 'pull' technologies, where individuals access project information from a single central source – i.e.: project-specific Web sites (PSWS) giving construction personnel new ways of 'pulling' information needed by speeding up information flows to design and build today's complex and fast-moving projects. The difference between push and pull communication methods are shown in Table 5-1:

Table 5-1: Push v Pull Information Distribution

JUST-IN-CASE INFORMATION (PUSH)	JUST-IN-TIME INFORMATION (PULL)
Out-of-phase timing	In-phase timing
High volume	Low volume
Irrelevant data	User-selected data
Organisation focused	Project focused
Inconsistent formats	Common format (HTML)

Case study approach findings suggest that the success of a PSWS is directly dependent upon the participation by key members of the project team – i.e.: key project players (including architect, project manager, superintendent and engineers) using the system on a regular basis. That while the Internet is undoubtedly here to stay, the speed and usability of project Web sites needs improvement before they will be fully embraces by the design and construction community. Regular participation can be enhanced through proper planning, training and promotion of a project technology champion.

The paper concludes, while the PSWS technologies are still in development, they show promise for improving and / or changing project communications. By 'pulling' project information from a Web-based system, project participants can evade traditional chains of command and eliminate many of the communication barriers inherent in 'push' delivery systems.

5.10 Case Study 10: Project Management (PM) in Construction: Software Use and Research Directions - USA

(Liberatore M.J., Pollack-Johnson B. et al. 2001)

Focusing on the use of project management software in the construction industry, the paper (based on an empirical study of project management (PM) professionals via a random survey of PM Institute members), identifies construction professionals as having different characteristics, needs and preferences. Researchers found that the initial usage of PM software increased slowly until the 1980s, further increasing after the introduction of the personal computer (PC). Thereafter the growth in users grew steadily until near saturation (over 90%) in 1992. Over the past five years, there has been a significant increase in the usage of PM software, particularly during the last twelve months where 97% of the construction respondents were recorded using PM software for project planning, presentation and control.

Additional findings included *project complexity* was the most influential factor used by construction respondents to determine when to use or not to use PM software, with *training and support* being the least influential factor effecting either use or non-use.

5.11 Case Study 11: Technology Adoption Decisions in Construction Organisations - USA

(Mitropoulos P. and Tatum C.B. 1999)

This research examines how managers from eight case study contactor organisations make decisions to adopt a new technology. The two technologies investigated are Electronic data interchange (EDI) and 3-D CAD systems. Researchers ask four questions:

- How does the need for technological change emerge?
- How do managers select and justify new technologies?
- Is innovation driven by company goals, powerful internal and external organisational actors, or does it happen when some organisational and environmental conditions simply allow it?
- How do managers deal with uncertainties involved in the adoption of a new technology?

In response to the above questions, researchers had the following three objectives:

Objective #1: Identify the decision-making processes managers use.

Four decision-making perspectives are presented:

- *Rational Perspective*: based on the fundamental assumption that human behaviour is driven by some purpose where managers enter a decision situation with known objectives –i.e.: gathers relevant information; develops a set of alternative actions; selects the optimal alternative; and implements the solution.
- *Behavioural perspective*: referred to as a 'bounded rationality theory of decision-making' which emphasises the difference between the rational and actual decision-making behaviour of managers?
- *Temporal perspective*: described as 'decision-making in highly ambiguous settings' and characterised by three main attributes: unclear objectives; unclear understanding of the ends-means relationship; and fluid participation (decision participants come and go from the decision making process). Stating that decisions are not the result of rational analysis but rather a random confluence of the following four elements: choice opportunities; organisational participants; solutions (looking for problems); and problems (concerns of organisational participants). As a result, decisions are made by chance rather than analysis.
- *Political perspective*: organisations are described as a 'coalition of conflicting interests', where decision-making processes is one of negotiation and conflict resolution, and were decisions are influenced by the most powerful, influential and authoritative of managers.

Objective #2: Identify factors influencing decision-making processes.

Investigations focussed on the decision-making processes in eight cases of technological adoption. Managers were faced with two major uncertainties: (a) uncertainty about technology selection and (b) uncertainty about cost justification. The study identified two main strategies regarding the approach of implementing a new technology, with emphasis on:

- limiting the consequences of failure; and
- maximising the likelihood of success.

Culture was identified as an important factor affecting the decision to adopt new technologies, but overall, the research found strong support for the following two decision-making processes (Table 5-2):

- Rational process: followed for technical decisions of strategic importance where company level decisions are made by top-management - focusing on maximising the benefits, selecting the best technology, and maximising the probability of success:
- Behavioural process: followed for project level innovation, where project managers (typically under budget constraints) focus on minimising the costs and exposure (consequences of failure), following an 'opportunity-based' and 'experimental approach' to technological innovation.

Table 5-2: Decision-Making Processes

DECISION STEPS	RATIONAL PROCESS	BEHAVIOURAL PROCESS
Decision Scope	: Senior management focus on a 'core' technology (critical for the organisational performance) and identify the most appropriate alternative to meet the organisational goal.	: Undertake a feasibility assessment of the available solution rather than an effort to identify the best technological alternative to achieve a specific goal.
Specification	: Contractors thoroughly investigate the performance of the technology for the specific process (e.g. detail capabilities) and how the technology would interact with interdependent processes.	: Decisions initiated by an idea to use a specific technology to improve a work process (solution driven).
Search for Alternatives	: Contractors undertake an extensive and thorough search for alternate options (4-6) and collect information from competitors and vendors – identifying limitations, potential weaknesses and implementation problems.	: Contractors do not undertake an extensive search for alternatives.
Evaluation	: Managers and technical staff are included in selecting the alternative that best meets the criteria - ensuring a good understanding of the technical risks: weakness, problems and customisation requirements.	: A feasibility assessment of the solution rather than a selection of the most appropriate option.
Cost Justification	: Focus on maximising the competitive benefits from the technology by: (a) quantifying the benefits v the costs of the technology and / or by (b) non-quantitative analysis (intuitive justification).	: No attempt to quantify benefits but focus on minimising costs ('guesstimate').
Implementation	: Management focus on maximising the probability of success and commit significant resources for extensive training and use of consultants.	: Implementation emphasised on limiting the consequences of failure and financial risk, rather than taking actions to increase the probability of success.

Objective #3: Investigate organisational and contextual determinants of innovation.

Researchers identify the following two factors affecting managerial decision approach to technology selection and cost justification:

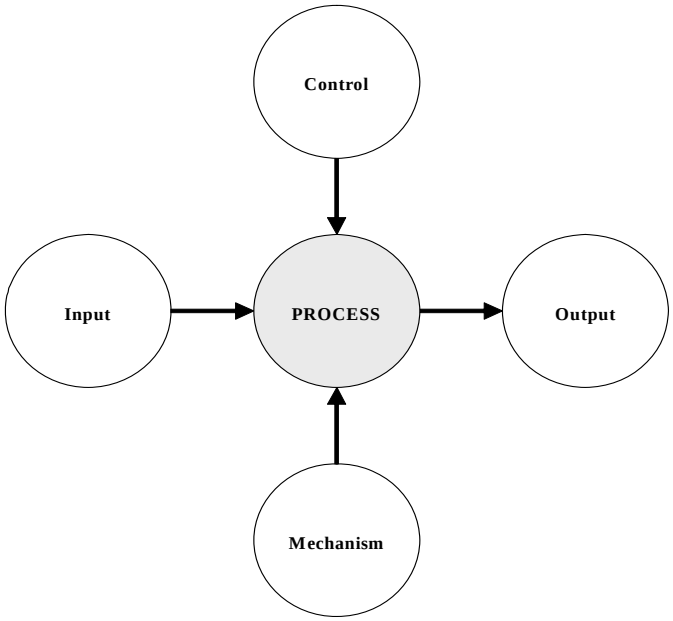
- Approach to Technology Selection:
  Decision importance and scope of technological change are the primary factors that influence how managers select new technologies – i.e.: when top managers consider an extensive (company level) technological change they follow a rational selection process with emphasis on selecting the best technology to meet the company's needs, while project level changes are found to be primarily solution driven.
- Approach to Cost Justification:
  The following characteristics are identified as playing an important role in a quantitative financial analysis:
  - High involvement of decision makers;
  - Intimate understanding of market conditions and customer needs; and
  - Extensive organisational participation.

5.12 Case Study 12: Anticipating Reuse: Documenting Buildings for Operations using Web Technology - USA

(Song Y., Clayton M.J. et al. 2002)

By exploring the feasibility of web technology as a means for delivering building information to better support facility operations, the research proposes a 'just-in-time' (JIT) facility documentation process as a pragmatic solution to the current limitations of as-built documents, thereby allowing more effective reuse of building information. The JIT documentation process is based on the information inputs, outputs, activities, resources and actors involved in the process (Figure 5-7).

Figure 5-7: Documentation Process



Current facility practices, involving architects, consultants, and facility operators from numerous other disciplines, produce information in a wide variety of formats. Due to the impracticality of having one unified structure for all this information (requiring agreement upon information / data format, contents and responsibilities), researchers consequently suggested adopting the strategy of an 'integrated document management system' that utilises Web technologies to compose and compound documents based on the needs of specific users to provide a practical solution among architecture, engineering, construction and facility management (AEC / FM) organisations, by gathering various formats of data and converting them to a minimum and common denominator (machine readable and semi-structured format) (Table 5-3).

Table 5-3: Examples of Generic Formats

DOCUMENT TYPES	REQUIRED FORMATS & STANDARDISATION
Drawings	• CAD format and Web-enabled format (d.g., DWG or DWF) • Sheet organisation standard (e.g. Uniform Drawing System) • Label names and equipment tags as provided by owner • Layer standard (e.g.: AIA CAD Layer Guidelines) • Embedded links on all scheduled items (e.g. mechanical equipment, .electrical equipment, control devices) • Use of symbols provided by owner
Product and performance data, (e.g.: schedules, test and balance reports)	• Spreadsheets or database with templates and fields provided by owner
Equipment operation and maintenance manuals	• HTML format and either Web or CD-ROM delivery PDF format - if HTML format is unavailable • Optical scanning if only paper based documents are available
Design intents	• XML documents type definitions and authoring tools
Work processes	• Documentation of processes through IDEFO, pseudo code or Web scripts

Findings suggest implementing the JIT prototype system will not be successful unless people rethink and reorganise the existing building process throughout its lifecycle:

- Collecting and storing information in the minimum required format (Table 5-3) may require additional responsibilities and expense.

- The process of capturing design intention, and creating simplified drawings and diagrams depends upon resources of personnel and training.
- Require agreements and consent among building owners and AEC / FM participants prior to implementation.
- An information administrator's role is very important and needs to be redefined – i.e.:
  - actively involved in collecting and storing information in a certain format;
  - analysing and creating task template;
  - managing link farm;
  - monitoring information uses and feedback for information update.

Research concludes by providing the following expected benefits (from using the Web-based JIT documentation process prototype system), and suggesting continued investigations of similar innovative technologies:

- Deliver necessary and concise information for operations: the system delivers:
  - necessary information - based on efficient operations task analysis results; and
  - concise information - on demand by incorporating diverse formats of information and filtering and customising information.
- Easy access to related information: The web-based interface is a familiar and powerful way to locate and retrieve needed information.
- Eliminate duplicated information and reduce re-creation time: the system reuses design and construction information, and eliminates duplicated information (saving time and resources) to create operations, maintenance and training documents.
- Reduce training time and efforts: the system provides onsite and online JIT training information - enabling potential users to learn how to operate building systems and components.
- Provide better update and reliability of information: the system provides an automatic workflow mechanism and redlining tool for updating and managing information efficiently.
- Provide quality assurance of information: the prototype system monitors information usage and utilises this information for strategic information planning.

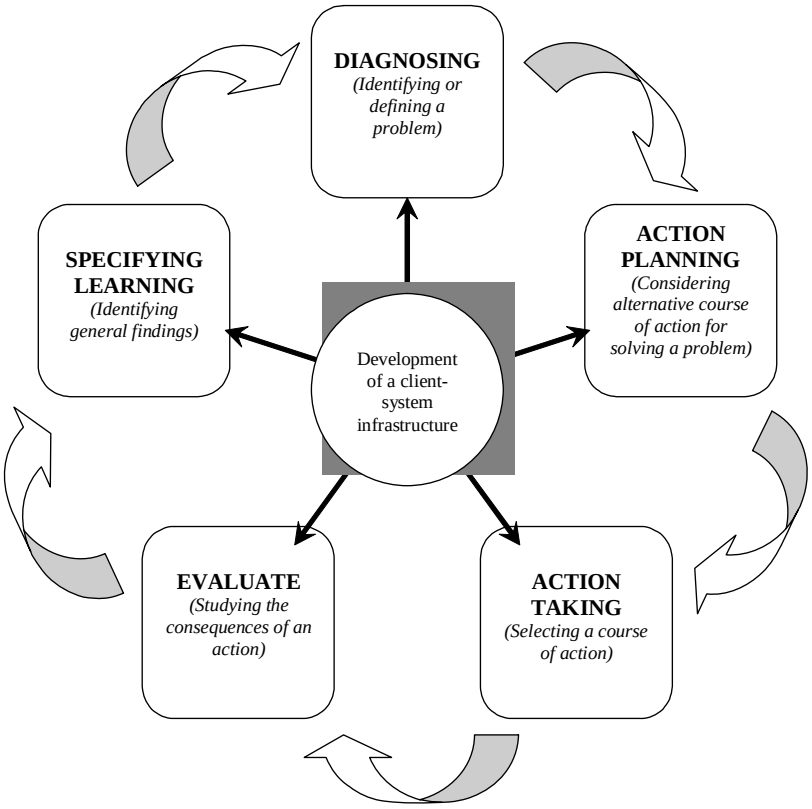
5.13 Case Study 13: Trying to Improve Communication and Collaboration with Information Technology – New Zealand

(Olesen K. and Myers M.D. 1999)

Emerging technologies, such as groupware products and the Internet, offer the potential to 'dramatically improve' the way in which people communicate and collaborate in the organisation of the twenty-first century. The use of ICT to facilitate communication and collaboration has become an important theme in information systems research and practice.

The action research project (enabling researchers to intervene in an organisation whilst generating knowledge about the process) discussed in this paper, was motivated by the desire to understand (more fully) the relationship between the introduction of groupware; changes in work habits; and the organisational structure of an organisation. The project involved introducing an ICT groupware product (Lotus Notes TM) to facilitate communication and collaboration among the senior management team of a tertiary educational institution in New Zealand. Researchers adapted a previously developed five stage 'action research cycle' methodology– i.e.: involving some form of collaboration between researcher(s) and practitioners to generate new knowledge that is useful for both research and practice (Figure 5-8):

Figure 5-8: Five Stage Action Research Cycle



Key to Figure 5-8:

- First phase (diagnosing): involves the identification of primary problems that are to be addressed within the host organisation.
- Second phase (action planning): specifies the organisational actions that should be taken to relieve or address these problems. These planned actions are guided by the theoretical framework of the action researcher.
- Third phase (action taking): implements the planned actions.
- Fourth phase (evaluation): includes analysing whether the planned actions achieved their intended effects.
- Last phase (specifying learning): specifies what was learned during the action research project – i.e.: when the knowledge gained is applied within the organisation and communicated to the research community.

Contrary to previous research activities (often occurring in a 'laboratory' / isolated environment - suggesting positive effects from the use of groupware), this project found that dramatic improvements in communications and collaborative activities proved elusive. Even though there was a real need for change, and senior management (initially supported by the enthusiasm of their personal assistants) approved the project (on the basis that it would enable radical changes in coordination within the workgroup), researchers found that it was much more difficult to obtain these benefits in the 'social situations' of an organisation. Due to these 'institutional forces' which inhibit any dramatic change in work habits', it is imperative to understand the social environment (organisational culture) within which a new ICT system or product will be used (preferably prior to its implementation).

The paper concludes with the following important findings:

- Use of ‘action research’ as a research method: whilst an action research project may not always be successful, its outcomes can still be useful as both researches and industry organisations can learn equally well from failure as from success. In this case, project participants welcomed the research results as providing important insights into the culture and norms of the existing organisation.
- Research results: it is important not to underestimate the power of the ‘counter forces’ which maintain the ‘status quo’ – i.e.: *it is one thing to install an ICT groupware product, but quite another to transform existing norms and ways of working*. Furthermore, these ‘counter forces’ can sometimes prevail despite the wishes of senior management (who in this case wanted to use ICT to challenge traditional organisational norms and ways of working). The ICT groupware product initially ‘worked' (used by all of the participants), but eventually existing (traditional) norms of communication and collaboration were reinforced.
- ‘Changing and embedding a new culture within an organisation is perhaps the new challenge of the twenty-first century’.

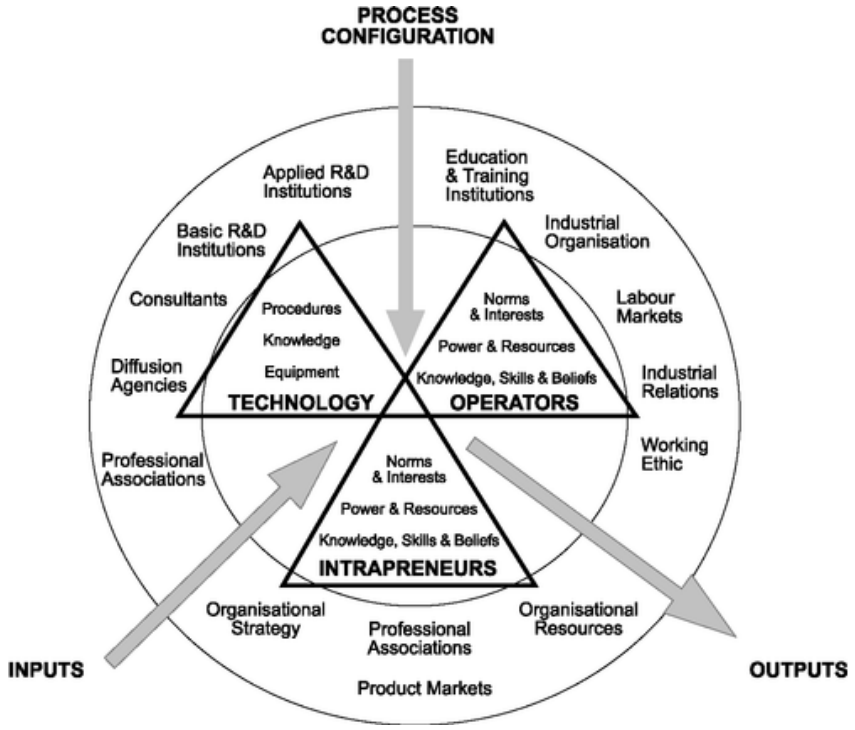
5.14 Case Study 14: Humanistic Redesign and Technological Politics in Organisations - Australia

(Badham R., Garrety K. et al. 2001)

The nature of technology (ICT) design and implementation is commonly dealt with in ‘human centred’ projects – i.e.: to introducing technologies that support job enrichment, group autonomy and industrial equality. As a result, the introduction of these technologies (into today’s organisations) is ‘political’ in both their origins and effects. The primary aim of this paper is to document and explore the detailed politics surrounding the design of workplace technologies and focus on applying a ‘generic socio-technical’ method or tool to create a more ‘human centred’ workplace technology - i.e.: a technology that places humans rather than technology at the ‘centre’ of a production process.

To ensure the transformation of relevant inputs into outputs in a specific organisational environment (shaped by cultural, economic and political factors), a conceptual model (initially developed to capture the complex processes associated with the introduction and operation of new production systems) is introduced to analyse the case study project - believed useful for appreciating and understanding the details of such processes (Figure 5-9).

Figure 5-9: Process Configuration to Effectively Influence the Design of Technologies



Extract from (Badham R., Garrety K. et al. 2001)

The above model involves the configuration of three organisational elements:

- Technology: the specific collection of knowledge, equipment and procedures that make up the structured, material, technical, 'non-human' elements of a design or development process – i.e.: more than just a simple or trouble-free 'application'.
- Operators: made up of local personnel who operate or use the design / operations techniques, incorporating their skills, attitudes, cultural interpretations, interests and roles. In this case study, the 'operators' included (a) expert facilitators (who communicated and applied the socio-technical tools), (b) the company technology developers and (c) the personnel whose activities were structured by the tools.
- Entrepreneurs: are included within the model as (a) they play 'key roles' in establishing and guiding the proposed configuration, (b) managing its boundaries and (c) ensuring its survival. Personnel carrying out these tasks on this project include project managers; line managers; staff officers; union officials and senior executives.

The political nature and impact of humanistic technology design projects is proven a result of complex collections of techniques (technology), users of those techniques (operators) and local entrepreneurs. The paper concludes by suggesting organisations avoid 'generalising' the 'political' implication of proposed technologies (e.g. ICT), methods and techniques introduced into the workplace. The proposed configurational process model is only one possible conceptual model to help researchers and practitioners grasp this perspective and understand the central role of technology design and implementation processes.

6 ADVANTAGES OF ICT ADOPTION

Measuring the benefits of ICT innovation and its implementation within the construction industry is not easy. This, according to (Andresen J., Baldwin A. et al. 2000), is due to there being numerous methods of its evaluation (none with a consistent approach within or across industry organisations) – i.e.: several based on traditional investment appraisal techniques (primary financial ratios) and others adopting a more subjective approach. ICT benefits can only be realised fully when the various technologies and systems are applied to specific and relevant tasks across several organisations and projects.

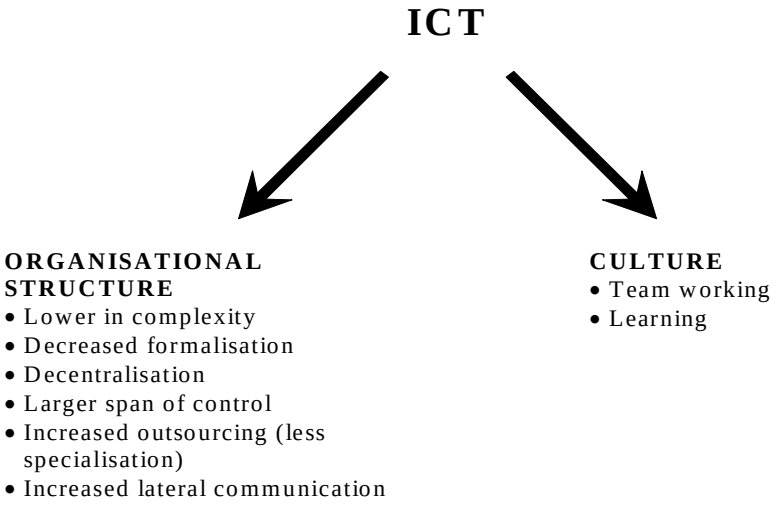
6.1 General

To further understand how ICT can provide long term benefits to the industry, by utilising ICT to create new ways of doing business and building value-added competitive advantages, (Fujitsu Centre 1998) established that the 'automation' of existing work practices provide a range of general benefits, including:

- productivity gains - companies who have re-engineered their business processes along with the adoption of ICT experienced significant gains in productivity and competitive advantage by enabled expansion into new markets and positioning them to compete internationally – i.e.: creating networks based on ICT across organisational, national and international boundaries;
- increased business turnover;
- shorter cycle time - a perception that ICT provides an expectation of faster cycle and response times;
- systems to manage larger and more complex projects; and
- improved accuracy and consistency of documentation.

Similar advantages are acknowledged in (Lau T., Wong Y.H. et al. 2001) where research activities focus on SME use of ICT, by monitoring its impact on organisational structures and cultures (Figure 6-1).

Figure 6-1: ICT Benefit and Impact



6.2 Project Level

The supply of appropriate, accurate information to the right people (when and where it is required) is a critical on any project. As a result the development and use of ICT systems has become the most important technology for the improvement of the construction process – i.e.: to support decision making in projects from early planning and conceptual stages through design, engineering and procurement, to erection, installation, commissioning, operation and facilities management (Gann D. 1997). Although there are many technical and implementation problems associated with the introduction of ICT to the construction process, the following benefits (from successful cases) can be experienced:

- Better integration of information flows between different firms in projects;
- Automation of routine information processing and communication activities within project teams; and
- Production of new information providing new levels of transparency about processes and facilitating further process improvements through the ability to acquire new knowledge, generate feedback and learn.

6.3 SME Professionals and Consultants

Potential use and benefit of ICT adoption experienced by industry professionals, consultants, suppliers, manufacturers, and small-to-medium-sized enterprises (SMEs), include (Fujitsu Centre 1998):

- **Architects:**
  - automated design and documentation;
  - electronic support for project administration;
  - support for presentation and marketing of design through rich multimedia software tools – i.e.: ability to demonstrate design using virtual reality simulation;
  - electronic document management;
  - significant productivity gains; and
  - ability to integrate work flows with increased levels of detailed design;
- **Quantity Surveyor:**
  - increased productivity through streamlined data entry and data management;
  - increased productivity through automated quantity and cost calculation;
  - faster measurement through use of digitisers;
  - elimination of measurement through direct calculation of quantities from CAD files; and
  - faster transmission of quantity and cost via email.
- **Consulting Engineers:**
  - support for calculation in analysis and design through specialist calculation tools;
  - use of email for communication with business partners;
  - use of advanced modelling tools to support more accurate analysis and design and meet performance-based design criteria – the development of IT-based design packages linked to analyse programs and drawings on previous standard details, has meant that documentation is increasingly becoming semi-automated;
  - documentation of building structure and survives using CAD;
  - use of computer-based workflow management and document management to improve quality assurance;
  - the development of knowledge-based systems in design and integration of design and cad documentation processes; and
  - joint venture opportunities with groups who have complementary design capabilities thereby providing single source solutions.
- **Principal and Specialised Contractors:**
  - electronic tendering with greater efficiency and accuracy in estimation;

- better project planning using 3D and 4D planning and scheduling software;
- better inventory management and reduced costs;
- computer-based workflow management;
- better contract / project management through data sharing, and document management;
- elimination of duplicate effort through improved access to information;
- better project control and coordination due to access to the latest / up to date information;
- better accounting / budgetary control and cash flow management;
- use of global positioning systems (GPS) for setting out;
- Improved safety management through the use of database systems;
- Cross-sectional integration to provide single source approvals;
- sourcing of components and materials using IFC's and from the Web;
- increased turnover;
- faster and cost effective communication with IT investments to pay for itself within two years;
- manage projects despite large distances between the head and site offices – including real time audio and visual linkage;
- overcome shortages of skilled workers by integrating processes through extensive use of IT in off-site pre-manufacture processes;
- early detection and resolution of problems related to project management; and
- significant reduction in rework and duplication.

- **Building Suppliers and Manufactures:**
  - integrated systems for optimising ordering and despatch;
  - integration of product design and manufacture – high productivity and efficiency with shorter product development times;
  - use of robotics to fabricate complex components and sub-assemblies off-site;
  - logistics and inventory management systems – just-in-time management of logistics and inventory;
  - Internet / Web-based customer and supplier interfaces;
  - electronic tendering;
  - executive information system for retail management;
  - sales force automation for mobile access to corporate / customer databases containing timely and customised business information for management and marketing – improved customer service;
- **Small-To-Medium-Sized Enterprises (SMEs):**
  - ICT offers consultant and contractor SMEs the same opportunities and potential benefits as those listed above for the larger enterprise architectural, quantity surveying and engineering sectors. The most significant challenge facing SMEs is the skilling of small organisations in the use of ICT (DCITA 1998).

6.4 Cross Sector

Generally, ICT applications are 'confined' to each sector of the industry, and any benefits experienced restricted to that sector. Cross-sector ICT advantages are threefold (Fujitsu Centre 1998):

- First, ICT is used to **improve the efficiency**, speed and quality of communication across sectors, thereby reducing cycle times and increasing quality for the whole supply chain.
- Second, ICT can be used to facilitate the creation of a **transformed supply chain** by taking a different approach to cross-sector relationships. By encouraging greater concurrency between tasks conducted by firms in different sectors through increased sharing of information can ultimately achieve substantial savings in time and money for the client.

- Lastly, ICT can **increase the total value** of the project to the client (operator) through improved sharing of information and knowledge (refer Section 6.6) between, for example, the design team, contractor and suppliers, encourages collaboration in identifying new and improved solutions to unforeseen problems on a project.

Industry participants who take up ICT can experience the following (a) 'knowledge' and (b) 'project process' development advantages and benefits (Table 6-1) (APCC 2000).

Table 6-1: Knowledge and Project Process Development Advantages and Benefits

(a) KNOWLEDGE DEVELOPMENT	
ADVANTAGE	**BENEFITS**
Develops a smarter industry	Improved profitability
Promotes cultural change	Improved long term viability
Improved industry integration and capability	Better application of innovation
Promotes innovation	Greater certainty of outcomes
Increased innovation take up through whole supply chain	Reduced cost of projects
Provides better access to industry and project information	Reduced social costs (fewer mistakes and accidents)
Avoids repetition of mistakes from project to project	Improved world competitiveness
Improves regional development	Increased opportunities for SMEs and regional enterprises
(b) PROJECT PROCESS DEVELOPMENT	
ADVANTAGE	**BENEFITS**
Focuses on value adding steps	Greater certainty of project outcomes
Assists culture change	Reduced costs for service providers and contractors
Improves industry integration	Reduces project cost
Improves project outcomes	Better project time delivery
Efficient management of assets	Reduced design and documentation rework
Assists decision-making through better quality information matched to need	Reduces material wastage Reduces response times
Helps control project costs	Better decision making
Minimise re-data entry	Increased flexibility in decision-making if circumstances change
Ability to record and access reasons behind decisions – leading to improved understanding of the decision-making process	Greater empowerment of project personnel
Provides greater choice of suppliers	Better acceptance of decisions
Provides local sourcing of maintenance	Reduces maintenance costs and faster delivery

Additional benefits gained from ICT integration for the various sectors include (Foresight 2000):

- provision of 'seamless 'solutions for customers;
- significant reduction in costs and elimination of mistakes;
- improved levels of inter-and intra-company co-operation and collaboration;
- better information sharing results in more effective use of resources and less re-work across construction projects;
- greater transparency in construction and operation costs will enable better long term planning;
- projects can be 'built in the computer' using simulation and visualisation prior to production work starting on site;
- reduction in on-site timescales and traffic movements and better on-site co-ordination and management;
- environmental gains in both resources and energy use;
- increased availability of information; and
- reduced costs of information gathering.

6.5 e-Construction

Arguably, e-Commerce has revolutionised the way today's companies trade and conduct business (Anumba C.J. and Ruikar K. 2002). Using e-Commerce in the construction sector can reduce paperwork; lessen re-keying of information; reducing errors; and provide a wider market reach. Additional advantages include:

- **Company / product promotions**: Using the Internet to promote a company or its products can facilitate:
  - a reduction in advertising and marketing costs;
  - provision of company information (products and services) through a Web presence;
  - easy access to target audiences from the construction sector; and
  - transparency with customers.
- **e-Procurement through search engines and Web directories**: Advantages include:
  - quicker access to construction-related information;
  - up-to-date product and industry information;
  - simplified procurement business processes;
  - cost savings through disintermediation; and
  - quicker product comparison in terms of price and quality.
- **Project management / online project collaboration**: Online collaboration tools can facilitate:
  - improved management of construction projects;
  - easier access to project information from anywhere at anytime;
  - faster transaction time;
  - enhanced transparency in the exchange of project information;
  - better collaboration between construction project partners;
  - increased time savings for communication of project information;
  - amplified savings on project cost; and
  - streamlined construction business processes.
- **Extranet:** The primary advantages of an extranet-based system include:
  - allowing various agencies in a region to work together via the Web;
  - establishing costs of the integrated system are low;
  - users have a choice of software and operating systems to communicate effectively;
  - provides open standards – i.e.: no need to concern with equipment compatibility;
  - minimal training is needed to understand the function of the system; with
  - relatively minor system maintenance requirements (Smith B.L. and Scherer W.T. 1999).
- **Virtual Reality (VR) Technology:** The use of simulation techniques (VR) can be helpful at the early stages of projects (Gann D. 1997). VR systems can provide a variety of advantages, including:
  - for client briefing;
  - bringing together / involving different interested groups located in different parts of the world in the planning process;
  - reduce risk and uncertainty in design decisions;
  - improve predictability decisions;
  - lower cost for making changes; and
  - saving time.
- **Digital Cameras and Video:** The implementation of digital cameras and video conferencing tools and systems, allows industry organisations to succeed in today's ICT dominated world, by enhancing and maintaining business and personal relationship on projects, whilst continuing the traditional 'face-to-face' approach of doing business (Linowes J.G. 1999). The ability of this 'enhanced, long distance, remote and face-to-face collaboration' amongst projects and team member organisations (through the use of visual facilities) is supported in (Graham M.B.W. 1996).

Furthermore, the use of 'time-lapse video applications' (instead of standard video cameras which take between 18 and 24 frames per second) can be used effectively for construction project management activities (Everett J.G., Halkali H. et al. 1998). By taking still digital pictures at selected intervals (commonly between 1 and 5 seconds depending on the amount of detail required), have several advantages, including:

- greatly reducing the amount of time spent viewing - whilst allowing viewers to accurately interpret construction operations;
- document weather conditions;
- resolve claims and disputes – leaving little room for faulty claims as well as support legitimate claims;
- for education, training and knowledge management;
- improve public and project relations;
- easily transmitted via the Internet to multiple parties at various locations;
- help prevent any unforeseen problems and discourage / capture trespassing, vandalism, theft, etc; and
- site personnel are conscious about their work performance, encouraging proper procedures to be followed resulting in improved safety, quality and productivity.

6.6 Knowledge Management (KM)

Knowledge management (KM) may be described as a process seeking to *'reduce duplication and increase innovation*'. Whilst many organisations are aware of the 'presence' of technological / ICT change, most are lacking the means to access it, learn it and ultimately, use it. Technological change is taking place at an ever-increasing rate. There is always a new product, new software - but until it is proven and widely accepted, many industry organisations seem unwilling to take the time to learn it. (CRISP 2000)

Knowledge is one of four levels of learning (Table 6-2) that gradually 'transforms' into organisational wisdom via: (Bierly P.E. (III), Kessler E.H. et al. 2000)

- transformation leadership;
- appropriate organisational culture and structure; and more importantly
- effective knowledge transfer mechanisms – i.e.: ICT tools and systems.

Table 6-2: Four Organisational Learning Levels

LEARNING			
LEVEL	**DEFINITION**	**PROCESS**	**OUTCOME**
Data	• Raw facts	• Accumulate truths	• Memorisation (*data-base*)
Information	• Meaningful • Useful data	• Giving form & functionality	• Comprehension (information-base)
Knowledge	• **Clear understanding of information**	• **Analyse & synthesise**	• **Understanding (*knowledge-base*)**
Wisdom	• Using knowledge to establish & achieve goals	• Discerning judgements • Taking appropriate actions	• Better living / success (*wisdom-base*)

From an ICT perspective, KM is said to be 'loose' and often interpreted as 'including a company's services' (Cleveland Jr. A.B. 1999). Various ICT solutions have been identified as significant contributors to the management of corporate knowledge problems, including:

- document management systems (DMS);
- data warehouse products;
- database systems; and
- expert system technology.

Any technology (e.g. ICT) designed to improve a business' or project's performance must support the way its employees and members accomplishes its work. According to (Cross R. and Baird L. 2000) many managers and organisations, due to dealing with large volumes of information, are turning to KM to achieve these improvements. A three step structured learning process for an employee is suggested:

- Target where learning needs to take place (areas of strategic importance);
- Provide a structure that encourages individuals and groups to share what they have learned from their experiences; and
- Build organisational / project memory by embedding the knowledge cultivated into ICT databases, work processes and support systems.

In order to overcome any 'cultural barriers' to sharing knowledge has more to do with how an organisation designs and implements its knowledge management 'effort' than with changing its culture (McDermott R. and O'Dell C. 2001). The following five summary lessons, from five (non-construction industry) case studies are provided – i.e.: by 'aligning' knowledge sharing with an organisations culture, where sharing knowledge is built into each:

- To create a knowledge sharing culture, organisations must make a visible connection between sharing knowledge and practical business goals, problems or results.
- It is believed more important to match the overall style of an organisation than to directly copy the practices developed by other organisations.
- Make the visible artefacts of knowledge sharing – i.e.: events, ICTs, language, Web sites, etc - match the style of the organisation, even when intending to lead the organisation into a new / improved behaviour and approach.
- Link the sharing of knowledge to widely held core values. People will not share their ideas and insights simply because it is 'the right thing to do'. By linking with core values of the organisation values, makes sharing knowledge consistent with peers' expectations and managers' considerations.
- These cannot simply be the additional or 'adopted' values in the company's revised mission statement – 'people do need to genuinely believe in them'.
- Human networks are one of the key vehicles for sharing knowledge, therefore organisations need to build a sharing culture, enhance the networks that already exist, and enable them with tools, resources and legitimisation.
- Recruit and support people in the organisation who already share ideas and insights.
- Ask influential people and managers to encourage and even pressure people to share their knowledge.
- Build sharing knowledge into routine performance appraisal - other people's behaviour, like alignment with business results and core values, is believed to be a powerful determinant of one's own behaviour.

6.7 Quality Management (QM)

A 'quality culture' requires implementation of a quality management (QM) system that is:

- employee and client orientated;
- generates action rather than reaction; and
- foster an environment of cooperation, mutual goal setting and teamwork (Strecker I. 1996).

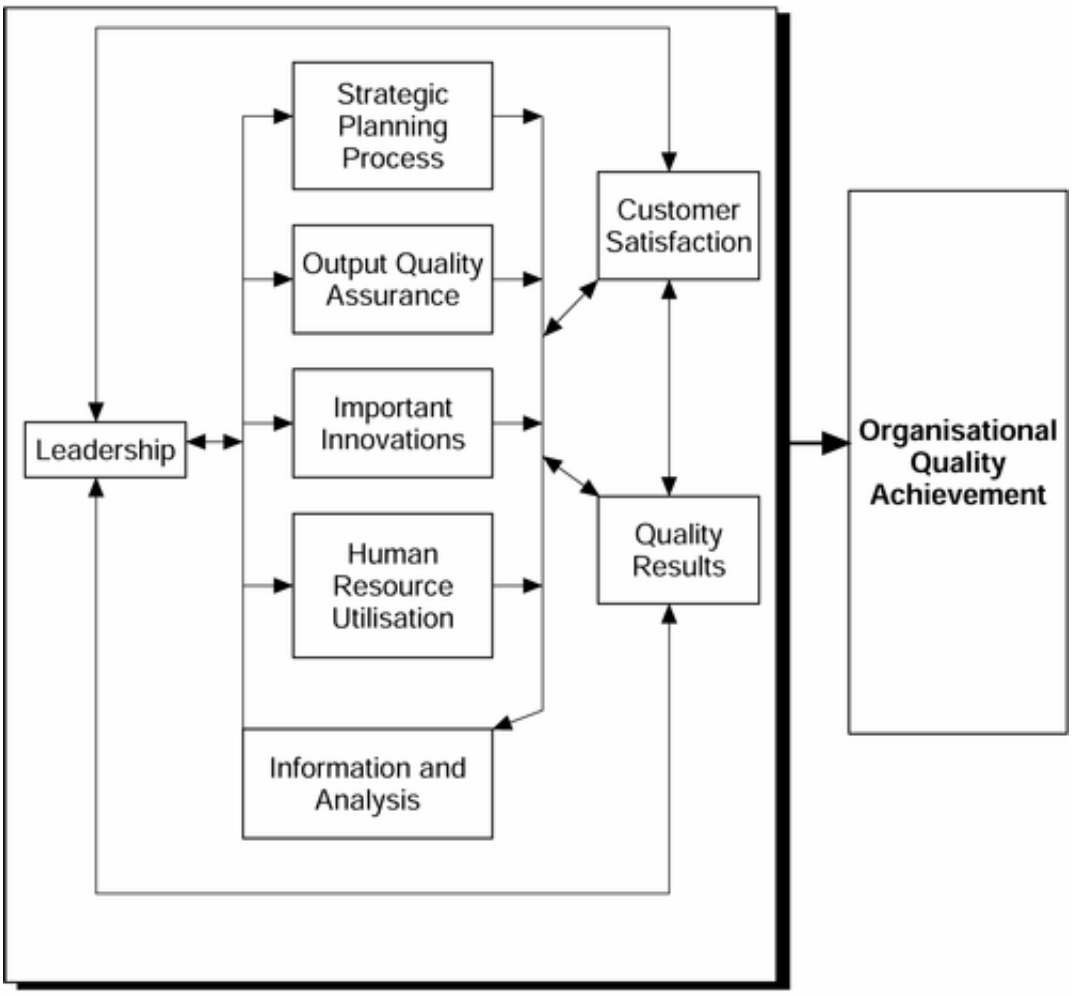
Harnessing ICT is the key to a successful QM system:

- Both internal networks and the Internet can continually be updated - making the latest critical information (now with reduced errors and losses) available on global bases.
- Improved training programs and computerised benchmarking activities (e.g. measuring compliances) provide feedback and aid in developing action plans (e.g.: CD manuals) to rectify inefficiencies.

- Furthermore, people are ‘empowered’ (not only as participants in the use of the system) but also as contributors in demonstrating ways towards ‘getting things right the first time, every time’ (Strecker I. 1996).

In order to measure the extent to which IT supports a QM process (Figure 6-2), the concept: ‘*quality management, supported by information technology*’ is investigated in (Ang C., Davies M. et al. 2000).

Figure 6-2: QM Process

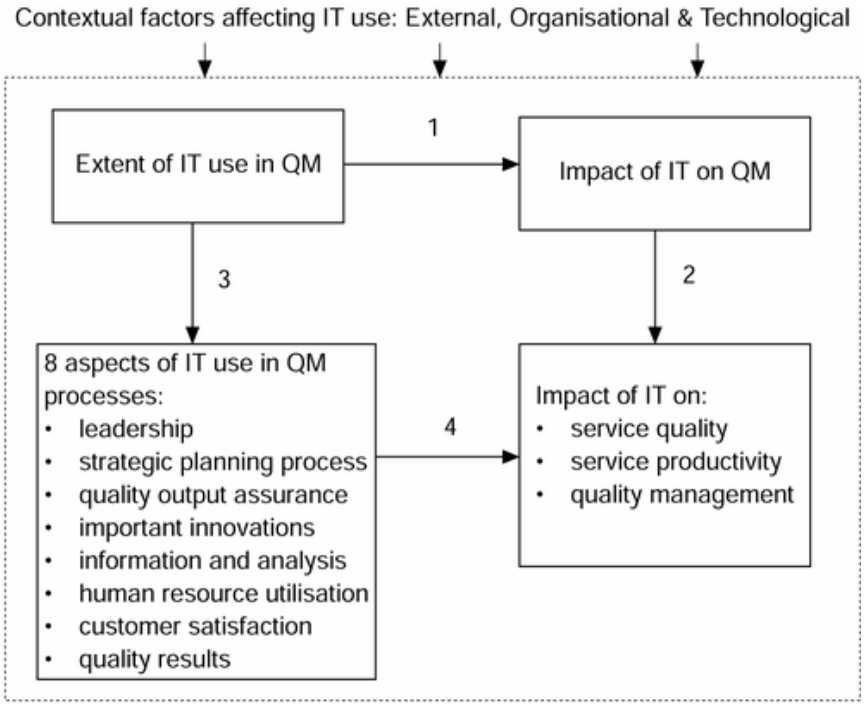


Extract from (Ang C., Davies M. et al. 2000)

Furthermore, ICT will have an impact on QM, but only if used in a QM process (Figure 6-3) – i.e.:

- The impact level of IT is directly dependent on the extent to which it is used to perform QM processes - relationship (1).
- How IT is used along the eight dimensions - relationship (3) - of the QM processes (derived through a process involving identification and synthesis of requirements prescribed by quality practitioners and academics).
- If the impact of ICT on QM and its effect on the organisational quality performance, service delivery and management is strongly related - relationship (2) - then relationship (4) can be used to test relationship (1).

Figure 6-3: ICT Use and Impact on QM Process



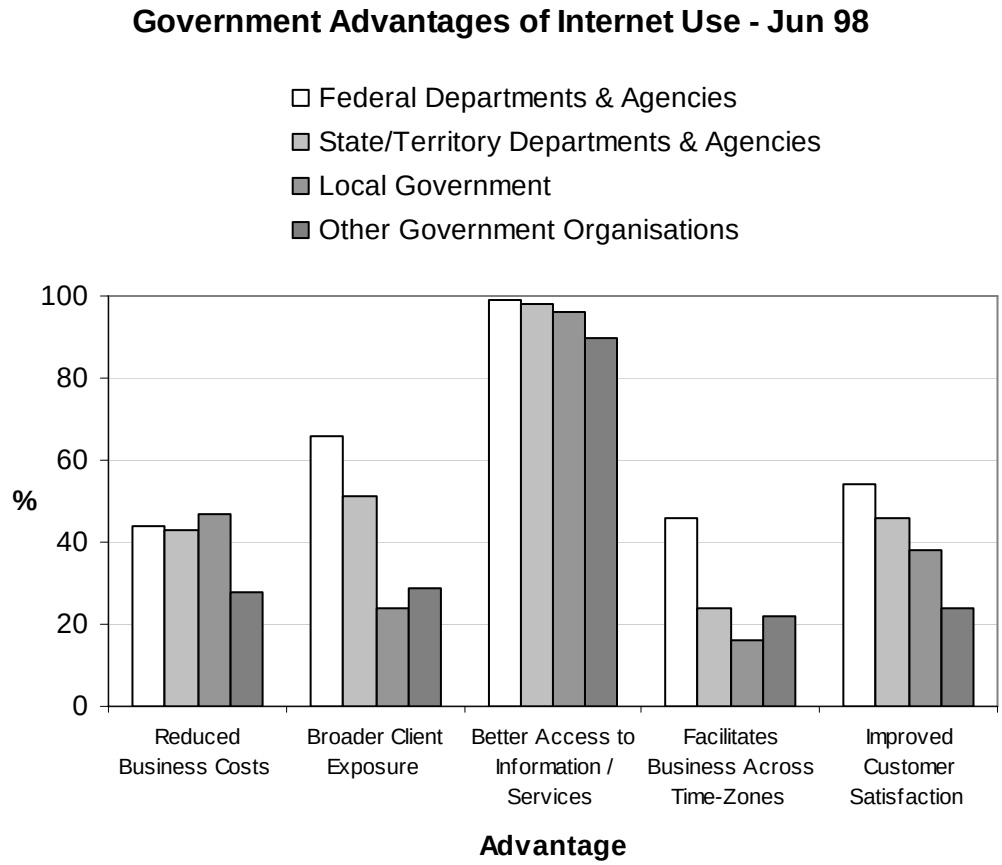
Extract from (Ang C., Davies M. et al. 2000)

6.8 Government and the Internet

This section covers the Australian Government's IT and Internet activities for periods 1997-98 (ABS 1999). The 1999 - 2000 issue of ABS Catalogue No. 8119.0 - Government Use of Information Technology (released 28 May 2002) - is not referred to in this section as it only covers the Australian Government's IT&T Expenditure and IT Employment statistics for that period. Referring to Figure 6-4:

- Of those organisations with access to the Internet (June 1998) - almost all (95%) identified 'better access to information/services' as a benefit of the Internet.
- A lower proportion of organisations experienced benefits such as:
  - 'reduced business costs' (39%);
  - 'broader client exposure' (37%);
  - 'improved customer satisfaction' (36%); and
  - 'facilitates doing business across time zones' (23%).
- 'Broader client exposure' was reported more often as a benefit by Federal departments and agencies (66%) than by State/Territory (51%) or local government (25%).
- 'Improved customer satisfaction' was reported as a benefit by 54% of Federal, 46% of State/Territory, and 38% of local government organisations.
- Only 1% of organisations with access to the Internet reported 'no benefits' to Internet use (ABS 1999).

Figure 6-4: Government Advantages of Internet Use – June 1998



7 DRIVERS OF ICT ADOPTION

Factors associated with successful adoption and implementation of ICT includes (Fujitsu Centre 1998):

- taking an incremental approach to ICT implementation;
- ensuring new ICT systems have business benefits;
- changing / re-engineering the organisation to take advantage of the technology;
- use of individual projects to fund incremental adoption and as an opportunity to learn to use the new technology;
- training and development of staff to be able to use the technology successfully; and
- top-level management 'buy-in'.

The following sections provide additional 'drivers' (identified by various international R&D activities), which may encourage individual businesses and industry organisations to readily adopt innovative ICT tools and systems.

7.1 Organisational

Four driving forces that motivate contractors to adopt a new technology were identified when researchers investigated the use of electronic data interchange technologies (CAD) in eight case study projects (Mitropoulos P. and Tatum C.B. 2000):

- **Competitive advantage**: The managerial goal of competitive advantage and keeping up with technology exists when:
  - the new technology improves a critical organisational capability; and
  - most competitors do not use a similar technology - as more competitors adopt a technology, the 'uniqueness' and 'differentiation' that early adopters had will be lost.
  - Additionally, better management of risk is required by:
  - thoroughly specifying the technological capabilities required;
  - selecting a technology closest to their needs; and
  - following an implementation strategy that maximises the probability of success, rather than minimising the risk.
- **Process problem**: For two of the eight case study projects, the adoption of a new technology was initiated by a 'problem'. A 'problem' is defined as a '*mismatch between the required level of performance (cost, schedule, quality, safety, etc.) and the actual performance*'. Problems such as increased costs, rework and delays during construction, increase over time due to:
  - changes in the firms supply factor: the reduced quality of design results in increased and unpredictable detailing costs;
  - increased complexity of high-tech facilities: a demand factor making previous 2D drawing technology unable to effectively communicate the design;
  - company growth: another demand factor that drives technological change in two ways:
    - as a company grows it undertakes larger and more complex projects with increased requirements; and
    - as the volume of work increases, existing processes often become unable to perform in a cost-efficient or timely manner.
- **Technological opportunity**: Referred to as a '*technological push force*' where the technology adoption for four of the eight case study projects was 'solution driven' – initiated by the identification of a technology, not a particular need or improvement goal. In all four cases:
  - the investment required was low,
  - the software and hardware were already available in-house,
  - failure of the technology would not effect the success of the project, and

- users required very little or no training – i.e.: a low cost experiment.

Researches identified the following factors to increase the technical and financial feasibilities of the technologies:

- increased organisational capabilities;
- availability of complimentary technologies; and
- reduced cost of technologies.

Furthermore, organisational factors that determined a company's sensitivity to technological opportunity were identified as being the:

- identification of potential long term and short term benefits: initiates the decision-making process;
- availability of 'slack resources': enables adoption of the technology (on a limited bases) without much need for cost justification; and
- availability of organisational capabilities: reduces the cost of the technology and the lack of resources required.

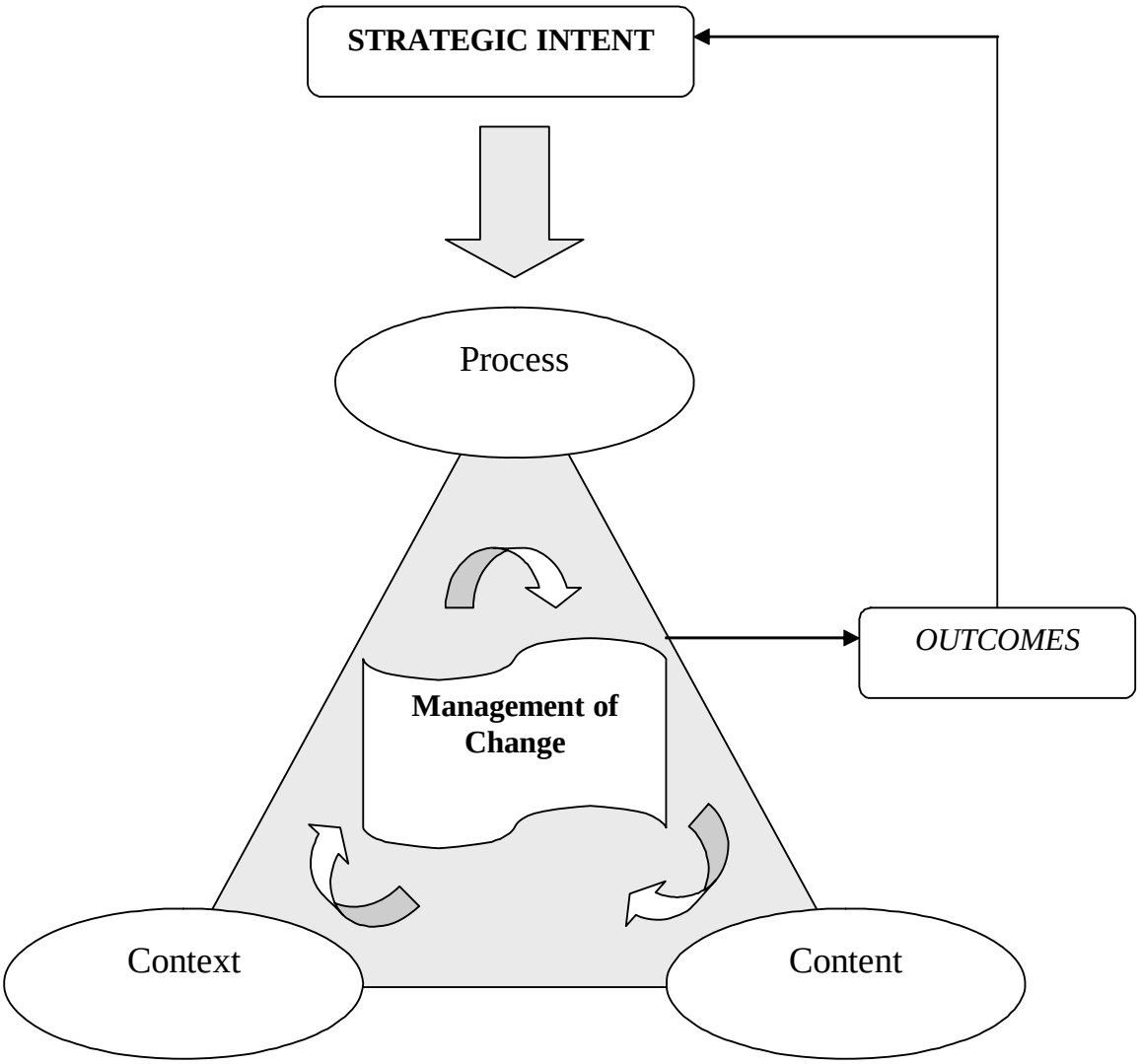
- **External requirements**: 'external actors' that drive the technology adoption process, identified by contractors as being:
  - Clients: often specifying project control technologies such as scheduling tools, cost control systems and email.
  - Competitors: the need to remain on 'equal footing' with competitors and identified technologies which have become industry standard. Further stating that a new technology used by competitors would not be adopted unless the technology gives the competitor a distinct advantage.
  - Regulatory agencies: although not influencing the use of CAD they dive the use of other technologies such as the use of safety technologies for occupational health and safety administration.

  Contractors with low technological capabilities and reactive attitude to technology are more sensitive to the above external requirements – i.e.: greater probability to adopt a technology because of external demands.

7.2 ICT System Performance

The rate of ICT system project failure remains high in comparison with other high-tech projects (Yeo K.T. 2002). Research has identified four integrated drivers of ICT system performance – i.e.: forces initiating strategic change through ICT system implementation, namely context; content; process; and outcome. Therefore, successful ICT performance is dependent on the management of a process that appropriately integrates content and context in order to achieve the desired outcomes that fulfils its strategic intent (Figure 7-1).

Figure 7-1: Drivers of Change



8 ICT IMPLEMENTATION BARRIERS AND CHALLENGES

Implementation is the '*challenge that comes at the end of all new (and old) methods for improving organisations*', including: architecture development, change management, total quality management and new ICT systems (Revenaugh D. L. 1994).

To follow, barriers and challenges identified during the investigation that individual businesses and industry organisations may be faced with during the implementation and application of innovative ICT tools and systems.

8.1 Australian Business Organisations

The top barriers to computer use by Australian businesses (June 2000) were (NOIE 2001):

- 'not suited to nature of business' (48% of businesses without computers) - down from the 63% at June 1998;
- 'lack of skills/training' (37%) - up from the 28% at June 1998;
- 'costs too high' (24%) - down from 32% at June 1998; and
- 'lack of interest' (21%) - not included in past surveys.

Additionally, an estimated 126,000 Australian businesses with computers did not have Internet access, of which the top barriers to Internet use were (NOIE 2001):

- 'not suited to nature of business' (54% of businesses with computers and no Internet access) - down from the 60% reported at June 1998;
- 'lack of interest' (26%) - not identified separately at June 1998;
- 'lack of skills/training' in the use of the Internet (23%) – similar 24% at June 1998;
- 'costs too high' (19%) - down from 30% at June 1998; and
- 'security concerns' (17%) - not identified separately at June 1998.

Organisations are face with increasing and long-term business process 'disruptions' caused by innovative ICT applications (Revenaugh D. L. 1994). These disruptive ICTs and how they affect traditions, is shown in Table 8-1:

Table 8-1: Affects of 'Disruptive' ICTs

TRADITIONS	'DISRUPTIVE' ICTs
Information appears in only one place at one time	Shared databases (Internet, Intranet, Extranet, etc)
Only experts can perform complex work	Expert systems
Businesses must choose between centralisation and decentralisation	Advanced telecommunication networks
Managers make all the decisions	Decision-support tools (database access, design and modelling software, etc)
Site / field personnel need offices where they can receive, store, compose and transmit information.	Wireless data communication (WAP, satellite, etc.) and portable / palm computers.
The best contact with potential clients is to be made personally (face to face)	Interactive communications (Web-based video conferencing, etc.)
You have to physically go through large amounts of information to find things.	Automatic identification and tracking technologies and software (key word search, information filtering and sorting, etc)
Periodic revisions need to be made	Limited upgrades of high-performance computing and ICTs

8.2 Construction Industry Organisations

A large number of (risk) factors or impediments are associated with the unsuccessful adoption and implementation of ICT (Fujitsu Centre 1998). The following implementation challenges need to be recognised and overcome:

- high cost of innovating or learning a new technology - due to tight margins for funding;
- fear of over-investment in ICT;
- industry reluctance to invest sufficiently;
- belief that ICT alone (without re-engineering / organisational change) can deliver promised benefits;
- resistance to reengineering / organisational change;
- lack of computer skills;
- lack of awareness of the opportunities;
- belief that ICT innovation is not necessary - that the industry is doing sufficiently without it; and
- client, senior partner and manager resistance.

Moreover, when it comes to assessing the 'cross-sector' use of ICT in the industry, a number of additional barriers are identified (Fujitsu Centre 1998):

- lack of people with an 'overarching' vision for the industry;
- fragmented and adversarial nature of the industry;
- lack of trust among firms;
- lack of shared language in which to understand the supply chain process; and
- lack of shared / common / compatible technology.

8.3 Choosing the Correct Implementation Strategy

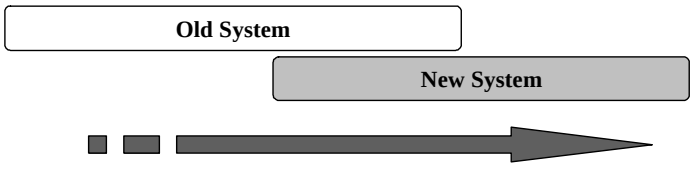
It is essential for industry organisations to consider the following four implementation strategies (Figure 8-1, Figure 8-2, Figure 8-3 and Figure 8-4) and select one that best serves the needs of the ICT application and user(s) (Table 8-2) (Paulson B.C. 1995):

- **Total Conversion:** The use of the old (existing) system is stopped and the new one is started or put in its place, on a fixed date (Figure 8-1).

Figure 8-1: Parallel Operations

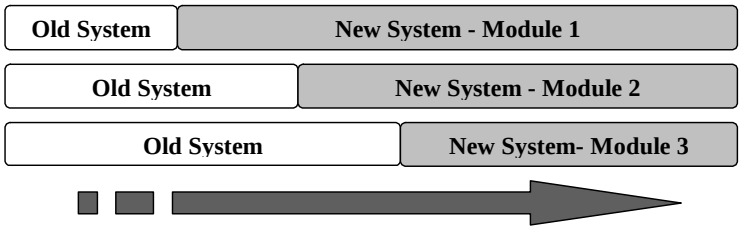
- **Parallel Operations with a Gradual Transition:** This strategy may be appropriate for a new and unproved system (Figure 8-2).

Figure 8-2: Total Conversion



- **Phased Implementation:** This allows separate modules to be added, over time, and eventually make up an integrated system (Figure 8-3).

Figure 8-3: Phased Implementation



- **Pilot Implementation:** Introducing the new system on a project that has interested and capable construction personnel with the motimation and initiative to try to make it succeed (Figure 8-4).

Figure 8-4: Pilot Implementation

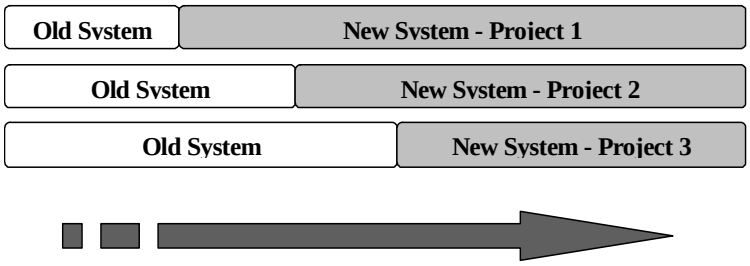


Table 8-2: Four ICT Implementation Strategies Compared

ICT IMPLEMENTATION		
STRATEGY	**ADVANTAGE**	**DISADVANTAGE**
Total Conversion	: Least stressful and trained users are ready to start immediately.	: If the implementation is poorly planned or the system is faulty, users may be demoralised, whose commitment is needed for success
Parallel	: One can check the new results against the old to ensure that all is going well.	: Double the effort is required in running both systems simultaneously and users may stall as long as possible to avoid learning the new system.
Phased	: Training and implementation workload can be distributed over a period where corrections and adjustments can be made.	: Possible difficulties of 'bridging' incompatibilities between the components of the old and new systems.
Pilot	: Two or more alternative packages can be tested concurrently and even if one of the pilot tests fail or is found to be unsatisfactory, the 'damage' is confined to one site.	: Not suitable for centralised systems.

8.4 e-Construction

Construction organisations are faced with many new challenges, including the need to: (Love P.E.D. 1996)

- change current work practices;
- become more client orientated;
- become more competitive; and
- become more productive.

The above challenges are attributable to the many factors that effect the working environment, such as:

- globalisation of the economy;
- greater performance expectations from the clients;
- increased competition between local contractors;
- continued restructuring of work practices, and
- industrial relations.

In spite of all the benefits e-Commerce provides (Section 6.5), in order to increase construction industry and public confidence in adopting these innovative ICT applications, (Anumba C.J. and Ruikar K. 2002) identifies the following two barrier categories:

- **General / common**: these mainly fall into three categories:
  - Infrastructure: although the Internet is referred to as a 'global phenomenon', the telecommunication infrastructure of several developing countries is insufficient to compete with their developed counterparts.
  - Trust and reliability: confidentiality, authenticity, integrity, security and proof of transaction must be developed and maintained.
  - Regulatory issues: unclear regulatory issues (e.g. tax, legal, financial, market access and ethical) are deemed 'major deterrents'.
- **Construction specific**: due to industry operations – i.e.: using '*arms length contractual relationships*', where the temporary nature of teams and relationships are formed only for the duration of a project - provides little incentive for investing in innovative ICT's such as eCommerce. Additional factors that limit the uptake of eCommerce in the construction industry include:
  - high cost of initial investment associated with building;
  - required infrastructure;
  - training of personnel;
  - quantifying the return on investment;
  - security of data; and
  - interoperability of software applications.

8.5 Information Overload and 'Gatekeepers'

Information overload is considered as a substantial drawback in the construction industry, caused (to a large extent) by information being 'pushed' onto other workers on a 'just-in-case-they-need-it' base. According to (Thorpe T. and Mead S. 2001) today's ICTs (developed to help solve and simplify project communication and information flows) are said to hinder productivity, because each worker must spend time:

- evaluating, responding or disposing each piece of information; and
- sort through piles of irrelevant information and data (in multiple of formats) to find one piece of information.

In addition to information overload, traditional reporting systems are identified as another communication barrier – e.g. where individuals or 'gatekeepers' restrict the free flow of project information by withholding information in order to gain a competitive advantage.

8.6 Project Related Failures

Failure, according to (Millet R.A. 1999) originates from: *not fulfilling a claim, promise, request, need, or expectation that arises in dealings between design and construction parties and the client*. Further identifying that only two to three of the following causes generate a

failure between main stakeholders of a project – i.e.: senior management, project management, technical staff, clients and their agents:

- recommendations not followed by client or contractor;
- lack of disclosure (or understanding by client) of risks, uncertainties, and consequences;
- technical errors or omissions;
- accepting limited scope of work;
- inadequate documentation;
- lack of staff training; and
- breakdown of communication between senior management, technical staff, client, and contractor.

Additionally, industry members who ignore the following during a decision making process (e.g. whether or not to implement an ICT tool or system on a project) will increase the failure of that implementation:

- clearly identify the critical elements of the implementation – be they technical or managerial; and
- identifying proactive, cost effective and preventive actions (Millet R.A. 1999).

(Yeo K.T. 2002) refers to the success or failure of developing and implementing ICT software systems as a function of managing the following 'critical failure factors':

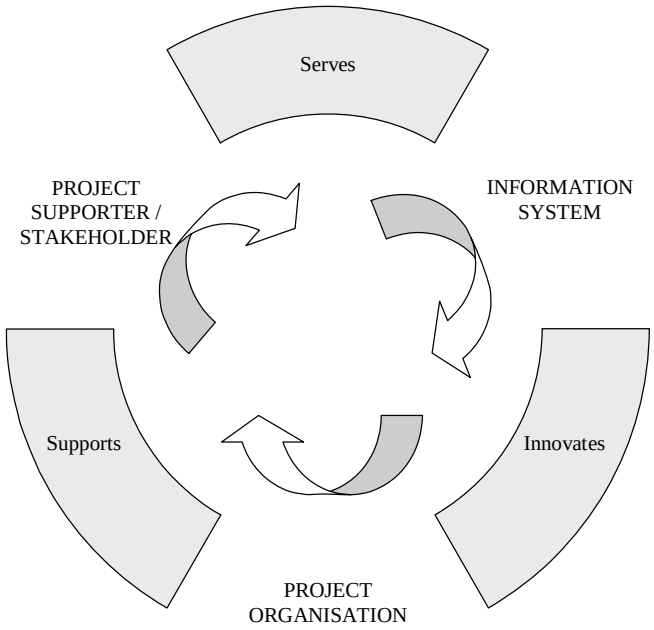
- organisational;
- financial;
- technical;
- human; and
- political.

The above failure factors are grouped in two categories:

- Failure factors (in the organisation and managerial context), including:
  - hostile company culture;
  - improper reporting structure;
  - political pressure;
  - vested interest;
  - influences; and
  - inappropriate levels of management commitment.
- Influencing factors (in the conduct of projects), including:
  - pre-occupation with the technology in project planning;
  - technology focus over human relations;
  - poor consultation;
  - design by committee;
  - poor stakeholder management;
  - underestimation of complexity;
  - technical fix for a management problem;
  - poor competency levels of project management and project team members; and
  - poor selection decisions.

In contrast, an ICT system (or its implementation) is not considered a failure as long as it 'survives' and continues to attract support in resources (Yeo K.T. 2002). With this support and commitment (from various stakeholders), the organisation is able to carry out its work (ideally with the view to serve the interest of those stakeholders) thereby creating a 'triangle of dependences' (Figure 8-5).

Figure 8-5: Triangle of Dependences



8.7 Inadequate Information Management

Due to the industry rapidly becoming a 'multidisciplinary, multinational and multibillion-dollar economy', involving large number of participants working together at dispersed locations and using various software and hardware technologies, it has become an information intensive industry, resulting in the establishment of a 'new' activity / discipline from the process of managing projects – i.e.: information management. Causes of limited approaches to managing project related information include (Rezgui Y., Cooper G. et al. 1998):

- large portions of project information stored on paper (drawings, written documents, etc) - frequently unstructured and difficult to use, and easy to lose or damage;
- initial intent behind decisions leading to project information not recorded or documented;
- people responsible for collecting and archiving project data may not understand the need, relevance or its future use;
- data not being managed while it is being created, but rather captured and archived at the end of the contract stage of a project;
- lessons learned are not organised and buried in details; and finally
- historical knowledge in reports is often lost when individuals leave organisations or move onto other projects.

8.8 Culture

'When we know what culture is, we know what needs to be changed for culture to change. Only once we appreciate its nature can we understand how it might be changed'. (Lewis P. and Thornhill A. 1994) and (Sadri G. and Lees B. 2001).

In an attempt to achieve the above, the following sections provide brief outlines and definitions of certain industry, ICT and international culture types, personalities, etc.:

8.8.1 Industry

(Michel H.L. 1998) identifies three basic types of construction industry 'personalities' (Table 8-3):

Table 8-3: Construction Industry 'Personalities'

CONSTRUCTION INDUSTRY	
TYPE	**PERSONALITY**
Undertakers	: leave everything alone
Caretakers	just flows with the tide and only takes care of things that supports their immediate environment – '*if it ain't broke don't fix it*'
Risk takers (innovators)	: the only ones who promote new technologies, new communication tools and takes on new challenges head on. Contradictory to the 'caretakers' of the industry, risk takers '*will fix it even if it ain't broke*'.

8.8.2 ICT

Every organisation within the industry has its own unique culture, character, nature, and identity. It has its own history of success, which reinforces and strengthens the organisation's way of doing things. Older and more successful organisations have stronger cultures, natures, and identity. Organisations are 'communities' of people with a mission and machine-like characteristics that serve the needs of the larger community. (Schneider W.E. 2000) and (Meudell K. and Gadd K. 1994). Today's global competitive business environment has made the culture of an organisation a critical aspect of its success (Sadri G. and Lees B. 2001).

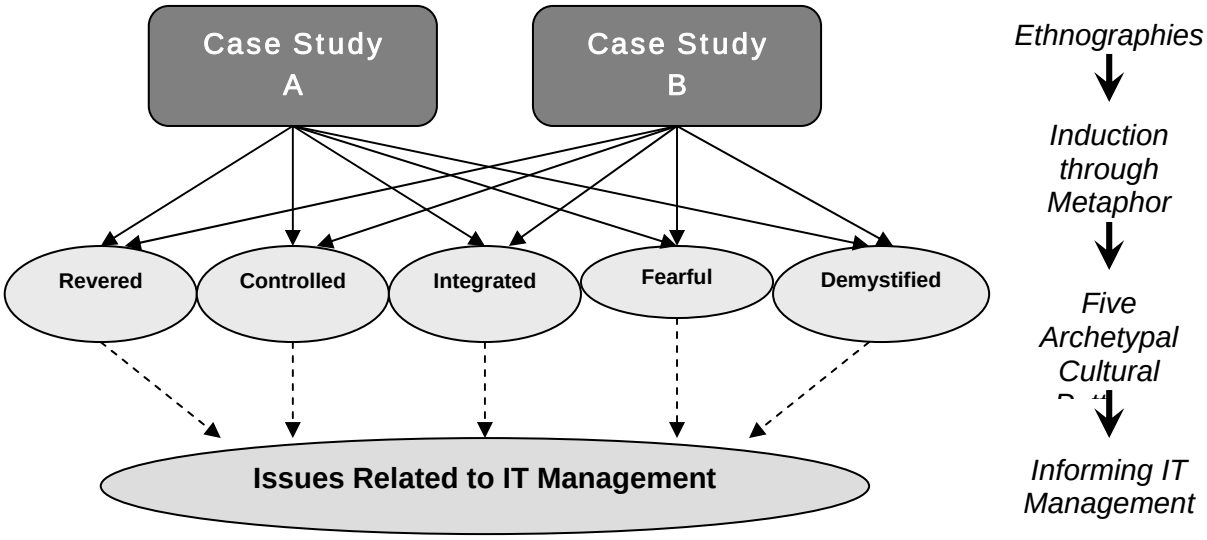
(Although the following research was undertaken within two large USA insurance organisations, construction industry participants can channel its findings, lessons and recommendations, and apply them to current and future ICT implementation projects.)

Studying two large (non-construction) organisations (ethnographies) and their staff's historical relationships, experiences and interpretations of ICT, and by employing metaphors – i.e.: '*magic dragons*' (to represent ICT), and '*wizards*' (to represent ICT specialists) - enabled (Kaarst-Brown M.L. and Robey D. 1999) to identify five archetypes of ICT culture. Even though the use of metaphors is regarded by some as 'never quite accurate', they are still accepted as an alternate, yet useful way to describe organisational cultures (Line M.B. 1999). The 'interpretation' of ICT cultures as a form of '*twentieth century magic*' is believed to:

- lend insight into the variety of ways in which ICT is managed within organisations and their cultures; and
- reveal some of the dilemmas associated with successfully integrating ICT with business needs.

Figure 8-6 provides an overview of the strategy researchers used for analysing the data (pertaining to management and implications of ICT) from the two case study organisations.

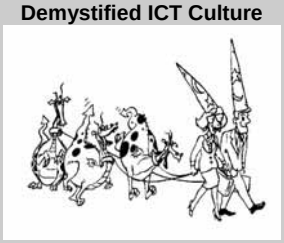
Figure 8-6: Strategy for Developing Five ICT Cultures



Importantly, the elements of each archetype culture were developed from both organisations – i.e.: neither organisation was associated with only one culture (Table 8-4).

Table 8-4: Five ICT Cultures

FIVE ICT CULTURES		
METAPHOR	**DESCRIPTION**	**IMPLICATIONS**
Revered ICT Culture  *'Dragon on a pile of gold'*	• ICT has significant positive impacts for the organisation • Honours those responsible for introducing ICT (does not criticise technology) • Innovation and championship behaviours are encouraged to support continual improvement through creative, effective use of ICT • ICT knowledge, skills and resources belong in the hands of those who understand them • Able to overcome gender bias (technology skills is the key to prosperity and promotion)	• ICT innovations experience little resistance • Early ICT adopter stand to gain competitively by applying it to their business needs • organisation becomes compliant with its ICT 'superiority' - getting blindsided in a crisis (not support emerging business needs) • conflict between those who understand ICT and requirements for successful implementation and those who make the decisions • ICT 'wizards' disregarding user dissatisfaction and frustration
Controlled ICT Culture  *'Caged dragon'*	• Neither 'dragon' (ICT) nor 'wizard' (ICT specialist) are trusted enough to be 'freed' and their 'magic' (abilities) are to guarded and controlled • Senior management (centralised) control with minimal interaction with lower level end users • ICT specialists are deprived (caged) members of the organisation – minimally involved in strategic directions as they are perceived by senior management as not having the necessary 'business knowledge' to understand strategic application of ICT, therefore receive and control few resources • ICT perceived as a 'necessary evil'	• Found to allow better integration of ICT and business strategies • Intensified competition resources between management and ICT specialists – 'whoever yells the loudest wins' • Lack of senior management ICT knowledge and skill effects innovative decision making – ICT aloud limited opportunities to influence strategic planning • Fail to develop adequate ICT skills • Senior management (usually older) tend to smother the (perceived threatening) ICT creativity of younger managers

Demystified ICT Culture  *'Pet dragon'*	• Inexperienced ICT specialists are unaware or unappreciative and only partially in control of ICT capabilities or opportunities • realising their own employment future depends on it, business employees are more aware of what ICT has to offer and develop / implement themselves - without accessing ICT resources ('self proclaimed wizards')	• ICT identification and application opportunities (and risks) realised through recruitment of employees that are 'self sufficient', 'independent' and 'self proclaimed' ICT 'wizards' and users • Discouraged reliance on ICT specialists • users solve their own ICT problems • tension between fragmented / duplicated ICT efforts of users and ICT management
Integrated ICT Culture  *'Team Dragons'*	• ICT, the specialists and users place equal value on each other's skill and capabilities (independently competent yet reliant on each other) – creating a positive and creative experience shared by all. • Business goals and client needs drive ICT innovation • Not widely supported	• due to ICT users and specialists willingly working together, ICT solutions to business problems can be positive achieved • teams do not necessarily function well simply because they were formed – e.g.: an innovative ICT is developed by specialists but poorly implemented by management / potential end-users • hard to sustain commitment is required • hidden agendas and problem solving rituals will cause the teamwork concept to fail.

Fearful ICT Culture
 
'Dead dragon'
	• rely on manual information processing (even if ICT is available and proven capable)
	• resist / mistrust ICT (automation) based on various rationales:
	  • inability to replace human intuition;
	  • inaccuracy of tool/ system processing;
	  • difficulty to correct tool / system errors; and
	  • mistrust of developers
	  • fear
	  • lack of knowledge, experience and skills
	  • introduce unnecessary risk
		• ICT mistrust may emphasise a greater concern for people – placing an innovative ICT under close scrutiny
		• Tend to continue manually until all ICT flaws are detected, corrected and potential benefits were realised by all
		• Transition from manual to automated to be gradual and 'as easy as possible for employees
		• Invest significant resources in training
		• Continued fear of an implemented ICT system limits further innovation and leads to under-utilisation

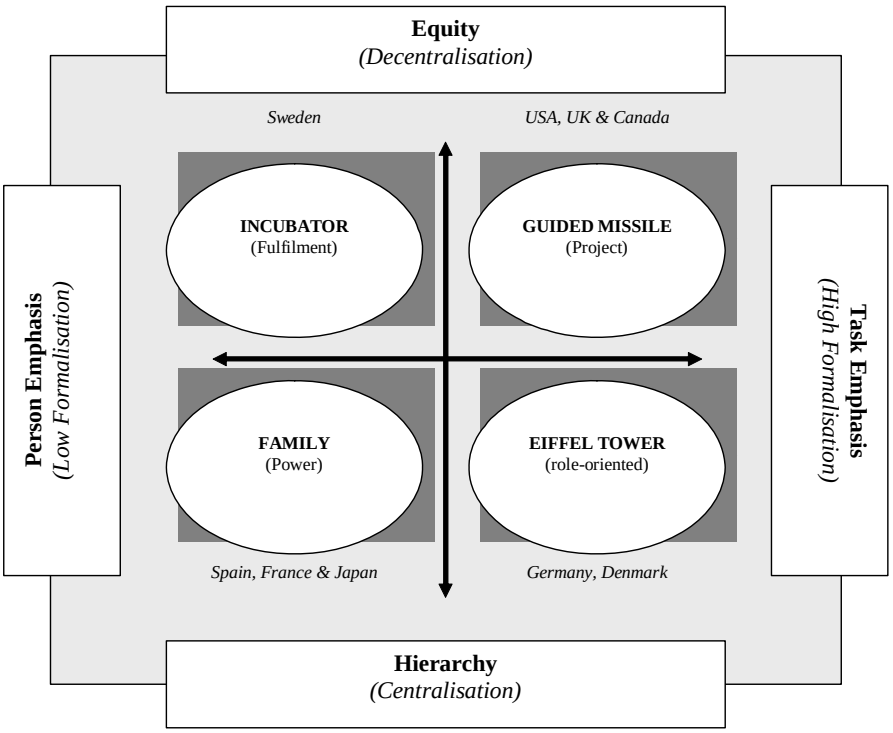
8.8.3 International

From an international perspective, (Joiner T.A. 2001) researchers compare the organisational cultures of nine different countries by referring to four International culture types (Table 8-5 and Figure 8-7):

Table 8-5: International Organisational Cultures

	COMPARATIVE DESCRIPTION
The Family (power-oriented)	: characterised by strong emphasis on the hierarchy and an orientation toward the person. Individuals are expected to perform their tasks as directed by the leader, who may be viewed as the caring parent. Subordinates not only respect the dominant leader or father figure but they also seek guidance and approval.
The Eiffel Tower (role-oriented)	: strong emphasis on the hierarchy and an orientation toward the task characterises this culture. The 'Eiffel Tower' image symbolises the typical bureaucracy - a tall organisation, narrow at the top and wide at the base where roles and tasks are clearly defined and coordinated from the top. Authority is derived from a person's position or role within the organisation, not the person as such.
The Guided Missile (task-oriented)	: characterised by a strong emphasis on equality and an orientation toward the task ('getting things done'). Organisation structures, processes and resources are all geared toward achieving the specified task/project goals. Power is derived from expertise rather than the formal hierarchy.
The Incubator (fulfilment-oriented)	: characterised by a strong emphasis on equality as well as an orientation toward the person. The purpose of the organisation is to serve as an incubator for the self-expression and self-fulfilment of its members.

Figure 8-7: International Organisational Cultures



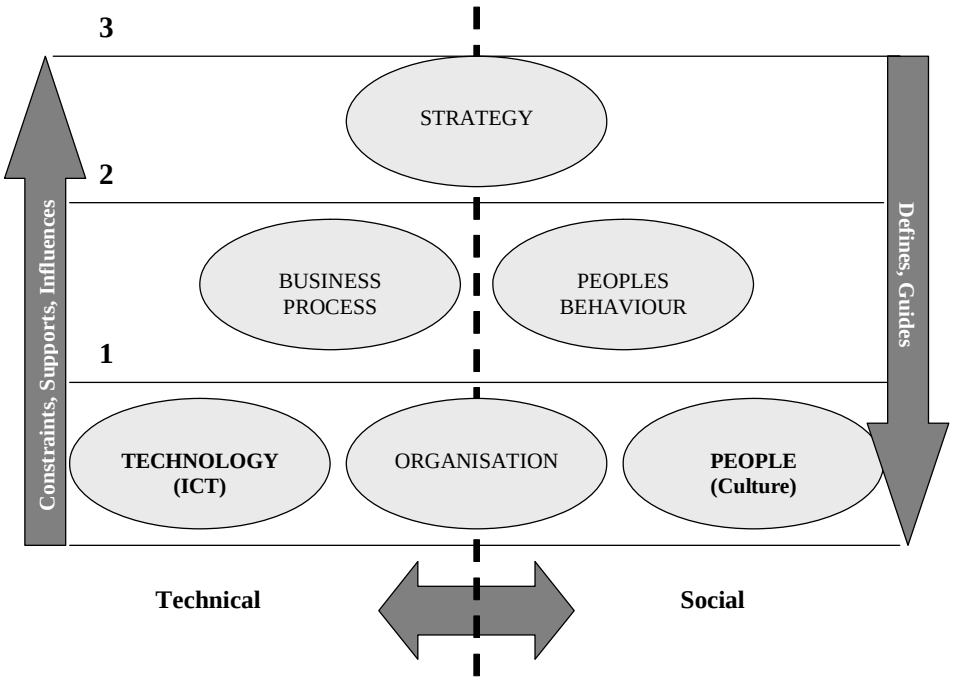
8.8.4 Additional Culture Classifications

Brief descriptions of an additional six 'common' culture groups, types, tribes, etc., found in today's organisations, can be viewed in Appendix B.

8.9 Technology Driven Change

The link between implementing innovative ICTs and organisational (cultural) change is not a new phenomenon (Uren D. 2001). According to leading UK ICT researchers and consultants (Cabrera A., Cabrera E.F. et al. 2001), 80-90% ICT projects fail to meet their performance goals due to organisations giving inadequate attention to non-technical (human and organisational) factors - termed 'critical determinants' of new system effectiveness. Organisations must realise when undergoing a technology (ICT) driven change, that ICT is only one of several inter-related components which drive organisational performance. Organisations must be able to efficiently manage the changes imposed (e.g. from introducing a new ICT) in such a way as to minimise the human costs of the transition while maximising the benefits from the technology. The paper acknowledges that the task of 'aligning' technology (ICT) and people (culture) is not an easy task, and that it is important to understand the interconnections between technology and people and their relationship with other important organisation sub-systems – i.e.: organisational structure; business and management processes; and strategy (Figure 8-8).

Figure 8-8: Organisational Performance Framework – Technical & Social Structure



Key to Figure 8-8:

- The bottom level (1) is referred to as the '*infrastructure'* or '*architecture'* level containing the 'long lasting pieces' of the organisation – i.e.: organisation's technology, its structure and its people (including the set of managerial practices that regulate the relationship between the organisation and its members).
- This supports the system of complex activities carried out by the organisation (2) which include *business processes* and *behaviours* .The organisation's processes and behaviours form the capabilities of the organisation.
- Finally, a more holistic view of the activity of the organisation is the organisation's *strategy* (3). Strategy refers to the way in which the organisation sees itself in relation to its stakeholders (customers, providers, shareholders, employees, government) and to the ways in which the organisation chooses to employ its resources in order to satisfy the needs of its stakeholders.

In addition, successful technological (ICT) innovation and implementation requires that either (a) the technology be designed to fit industry organisation's current structure and culture or that (b) the organisational structure (processes) and its culture (people) be reshaped to fit the demands of the new technology (Cabrera A., Cabrera E.F. et al. 2001). Suggesting industry organisations consider the following when faced with technology driven change:

- The implementation of a new technology (ICT) can unbalance an organisation and its subsystems. Successful ICT integration depends on how well the organisation and its subsystems absorb these disruptions and adapt to a 'new equilibrium'. Failing to achieve this new equilibrium will result in a waste of time and resources.
- This equilibrium must be viewed along both *vertical* and *horizontal* dimensions (Figure 8-8) :
  - Vertical: refers to the alignment between the new ICT, the capabilities of the organisation, and its strategy. As there are no 'coherent universal technologies', a technological innovation would be invaluable to industry organisations, if it can contribute to generating the capabilities necessary for the organisation to achieve its objectives.

- Horizontal: refers to the integration between the social and technical subsystems of the organisation. To successfully adopt a new technology, organisations have to adapt its structure and its human resource 'architecture' in a way that allows the new technology to be used by the right people in the right way and at the right times.
- Changes in the organisation's core technology will often challenge existing procedures and decision-making policies, and force the 'modification' of existing jobs and job assignments.
- The people subsystem – i.e.: the norms, values and basic assumptions shared by people within the organisation - provides a valuable medium to assess and manage technology driven change.

In summary, organisational culture is a 'key construct' in understanding and managing the behaviour of people within the boundaries of an organisation and in implementing a technical (ICT) driven change (Cabrera A., Cabrera E.F. et al. 2001).

8.10 Culture Driven Change - *Technology Is Not Enough*

Arguably, today's Industries, businesses and personal worlds are dominated by a wide range of technologies and e-activities, including: computers, email, Internet, Web sites, etc., finding it more and more difficult to function without them. Travelling along the information 'super-highway' is crucial for information exchange, information gathering, speed and ease of doing business (Linowes J.G. 1999). Yet, the success of any profession is described as going beyond simply exchanging electronic information. That successful ICT implementation requires careful consideration to the 'human touch' (Claver E., Llopis J. et al. 2001) and (Gore Jr E.W. 1999). Future development in determining new / improved ways of doing business through ICT tools and systems, and the Internet is dependent on the innovation of the user, not the technology itself (Ahmad I. 2000).

An organisation can have the optimum ICT implementation strategy, but if its culture is not aligned with and supportive of that strategy, the strategy will either stall or fail (Schneider W.E. 2000). The last available mechanism left for organisations to improve their competitive position is by considering people (human resources) along with technology. By employing a dedicated, highly skilled, flexible, co-ordinated, committed and productive workforce, coupled with a leaner, flatter and more responsive organisation will ensure a more effective and successful implementation of innovative technologies (ICTs) (Morley M. and Heraty N. 1995).

Furthermore, when considering the implementation or adoption of new ICTs into long-established organisational arrangements and multiple work cultures, one can not assume once electronically and simultaneously linked, that it will automatically ensure an increased sense of community, improved ability to collaborate or improved understanding of others (Graham M.B.W. 1996). On the contrary, organisations and ICT users are now faced with increased burdens of interpretation – e.g. regular (mostly unintended) mistakes and misunderstandings. The argument is further supported by considering the following questions:

- Which is considered more urgent: a voicemail message, an email message or a fax?
- What is the appropriate medium for having what kind of communication?
- How are these issues to be decided?
- How is it possible to decide in the midst of collaboration with people and organisations of differing experiences, media and preferences?

Many managers assume people turn to technology, databases or policy procurement manuals to obtain information. Yet, according to (Cross R. and Baird L. 2000), people usually rely upon a network of relationships for information and advice – i.e.: rather than turning to a capable technology, database or other sources of electronic information, employees are five

times more likely to turn to friends or business colleagues for answers. Technology is described here as simply: 'a tool for building relationships; facilitating the exchange of ideas among colleagues'; and only one form of 'memory' that employees tap when solving problems – i.e.: its use is limited (Cross R. and Baird L. 2000).

Companies who wish to become that 'excellent' company and experience increased competitive advantages (from implementing an innovative ICT to implementing a ICT training evaluation program), may very well have to (additionally / simultaneously) introduce a 'cultural change program' that gradually 'cultivates' the existing culture to accept change, (rather than rely on the outcomes of traditional / outdated management-led initiatives) (Lewis P. and Thornhill A. 1994).

However challenging or far reaching the essential results may seem, they are achievable by implementing the following 'change program activities' (Lewis P. and Thornhill A. 1994):

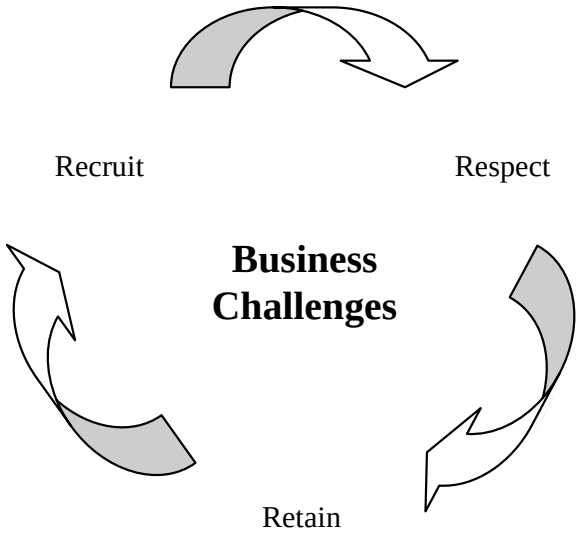
- **Defining the desired goals:** described as the difficult task of defining clear, measurable, and time-specific goals of attitudes, beliefs, and behaviours of personnel.
- **Analysing the current state:** referring to earlier research (Lewis P. and Thornhill A. 1994) recommends this form of analysis can be achieved by comparing the organisations driving forces against the restraining forces (Table 8-6) – i.e.: factors likely to promote change to those factors likely to hold back change.
- **Reviewing the change strategies available:** various approaches to achieve organisational change are to be considered.
- **Deciding on the appropriate strategies:** even though this is proven to be a difficult task, researchers suggest answers to the following questions are potentially useful when deciding on which strategy to adopt:
  - *Are the strategies likely to gain the support of those who will play a part in their implementation (particularly senior and line managers)?*
  - *Do the strategies have the potential for yielding useful data quickly?*
  - *Have I and others (involved in the process of data collection), sufficient expertise to conduct the strategy successfully?*
  - *Are the strategies too expensive and time-consuming?*
  - *Are the strategies likely to involve those concerned with the implementation, being embroiled in organisational politics?*
- Implementing and evaluating the strategies: based on (a) the answers to the above questions, (b) continuous monitoring and (c) ending with a thorough review.

8.10.1 Invest in People

In an attempt to 'radically improve' the industry's performance on 'people issues', a working group was set up and charged with identifying practical and effective ways in which the construction industry could improve its performance (Rethinking Construction 2000). Research outcomes identify the 'failure' of leading firms 'respecting people' potentially caused irreparable damage to their 'bottom line'. In addition, the 'gap' between the 'respect' demonstrated towards operatives (blue-collar workers), and that shown for white-collar workers (management), is identified as perhaps most damaging of all.

Therefore the most urgent business challenges currently facing the industry is not the implementation of innovative technologies (e.g.: ICTs), but 'looking after people' (Figure 8-9) – i.e.: companies who fail to improve their attitude and performance towards **respecting** their own people and others, will fail to **recruit** and **retain** the best talent and business partners (Rethinking Construction 2000). This challenge is also recognised in (Linowes J.G. 1999) where '*holding on to good people'* is regarded as today's management challenge. Further stating that today's talented professionals are highly sought after yet have increased opportunities in choosing the most appealing work environment.

Figure 8-9: Industry Business Challenges

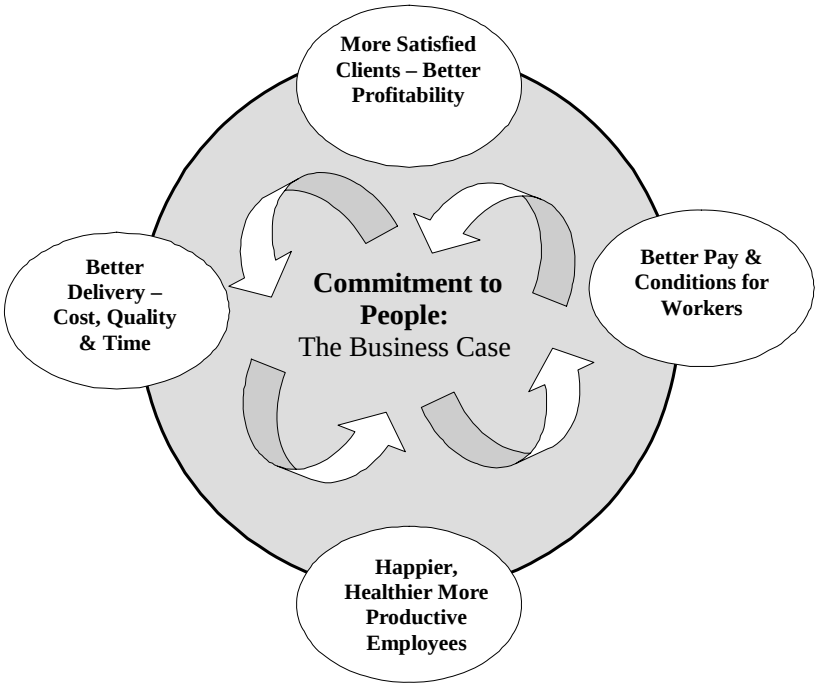


Furthermore, all firms large or small, specialist or supplier, consultants or constructors, etc. (i.e.: all parts of the supply chain) should quickly realise the benefits if they practice to respect and include their people in a decision making process (e.g. implementation of a new ICT tool / system that will ultimately effect them and the way they currently operate). Resulting in all those working in a firm or on a project experiencing a level of professionalism (unknown in the past), and leading to benefits including (Rethinking Construction 2000):

- a better standard of work;
- more cost effective projects;
- fewer delays and expensive mistakes;
- fewer accidents and less ill health;
- reduced staff turnover;
- earlier completion dates;
- an advantage over competition; and
- increased repeat business.

The renewed respect and involvement of organisational and project personnel are supported in (Rethinking Construction 2000) – i.e.: to ensure improved and overall performance, it is important to involve, engage and empower all people in issues that directly affect them (Figure 8-10). Further supported in (Graham M.B.W. 1996) stating ‘non-technical people’ need to take their share of responsibility to ‘bridge the gap’ between those who invented / developed work supporting technologies (e.g.: ICTs) and those who ‘criticise’ innovative technologies as ‘unappealing’ and ‘unsupportive’ of their work.

Figure 8-10: Business Case for Commitment to People



Finally, people are (generally) more committed to plans and activities (e.g. implementation of an innovative ICT) when they share the ownership of those plans. This 'employee participation' is essential, because any organisational policies and plans will have an impact (in one way or another) on their 'working' lives (Baines A. 1998). Yet, on the other hand, these 'ownership cultures' can also fail due to:

- Employees having 'initiative fatigue'.
- Even though employees are generally / initially receptive, they may not understand the 'proposal' due to it being too complex, unconventionally written (too technical) or presented (different format).
- 'Managers listen - yet do not change' as they may be threatened by perceived 'disempowerment'.
- New or Improved plans, suggestions, recommendations, alternatives, methods, etc., are not supported by appropriate and timely actions from decision makers.

8.10.2 Trust in Project Teams

Due to the 'complexity and turbulence' of today's global business environment, a move towards 'team-based organisations' is suggested, by changing the way people currently interact and work within industry organisations. Furthermore, the success of implementing these 'autonomous' / self-directed / cross-functional working teams (to boost effectiveness and productivity) is dependant on conducting an organisational culture and structural analysis prior to its implementation (Tata J. 2000) and (Unknown 1997). Yet, although many organisations believe and trust in the teamwork concept of: having regular team meetings; sharing of ideas; experiencing 'spirit' of team work; and realise the potential benefits it can bring, it is not easily achieved or maintained (Hiley M. 2001).

The construction industry is an integral part of any country's business environment and its 'problems' lie with all its participants, not just the '*hard hats*'. These 'problems' can be

overcome if industry participants simply learn to trust each other (Michel H.L. 1998). The current lack of being able to trust each other (e.g.: due to the fear of litigation, etc.) has caused the industry (as a whole) to go from '*risk takers*' to being '*caretakers*' (Section 8.8.1). These industry and project team 'personalities' (cultures) can be described as follows: *There were three men doing the same task on a construction site. When asking them what their task was, the first replied 'breaking rocks', the second 'earning a living' and the third 'helping to build a cathedral'* (Michel H.L. 1998).

To ensure a successful and effective project team, it needs to be embraced by its members as a 'total discipline' – i.e.: applied constantly; during formal and informal discussions; in times of project related (as well as personal) crisis; and any other everyday interactions (Hiley M. 2001). Therefore, the industry is advised to develop an 'indisputable code of ethics' that emphasises integrity and trust in all its activities, thereby encouraging an increase in its participants to '*help build cathedrals*' rather than continue to simply '*break rocks*' (Michel H.L. 1998).

8.11 Resistance to Technological Change

The industry has to realise that investing in ICT is no longer primarily buying a piece of hardware or software. It is now more of a potential long term investment in the process of change itself (Cleveland Jr. A.B. 1999) and (Buch K. and Wetzel D.K. 2001). Unfortunately, the nature of the industry's constructed products, and its organisations and processes, limit technological change within the industry (Gann D. 1997):

- site-based nature of erecting, assembly and installation, together with the need for durability, signifies that firms often prefer to use (what they consider to be) tried and tested techniques, tools, systems, and processes, etc.;
- buildings and structures becoming more complex - often involving the integration of expensive systems; and
- legacy of sunk costs.

The use of Table 8-6 is recommended as a tool to compare an organisation's driving forces against the restraining forces in order to determine any 'resistances' to change (e.g.: implementing an innovative ICT). Change can be effected by strengthening the driving forces, or by weakening the restraining forces, or both – i.e.: by (a) 'unfreezing' existing forces, (b) introduce change (geared to re-establishing the 'equilibrium of forces') and then (c) to 'refreeze' the new situation. However, strengthening the driving forces without weakening the restraining forces is likely to place strain on the system (Buch K. and Wetzel D.K. 2001).

Table 8-6: Forces of Resistance to Organisational Change

DRIVING FORCES	RESTRAINING FORCES
• Dissatisfaction with current situation and acceptance	• Fear of the unknown and feelings of insecurity about need to change
• Impact of environmental factors	• Disruption of routine and usual patterns of behaviour
• Momentum towards change – the domino effect	• Loss of face
• Motivation by consultant	• Threat to the power base and other vested interests
• Commitment of top management	• Blindness to the need to change • Group norms and values

Supporting the above recommendations in how to deal with the forces of resistance (Table 8-6), (CRISP 2000) suggests a similar 'force-field' analysis be implemented – i.e.: to map the driving and restraining forces to technological change (Table 8-7).

Table 8-7: Technological Change Force-field Analysis

DRIVING FORCES	RESTRAINING FORCES
Innovation	Time to market
Cash for knowledge	Competition
Long term cost benefit	Initial development cost
Competitive advantage	Risk of failure
Time saving	Initial development time
Quality improvement	Awareness of track record
Education	Knowledge sharing
Financial incentive	Understanding of process

Moreover, it appears advantageous for implementers (e.g. of an innovative ICT tool or system) not to 'camouflage' the true nature of a change prior to its implementation – i.e.: not to portray the change as less dramatic and positively beneficial to the staff and the company. This 'clouded' staff 'programming' is the grounds of resistance towards technological change (Hughes T., Williams T. et al. 2000).

8.12 Training

In many organisations, the single biggest expenditure is its payroll (in some cases as much as 60%). Therefore to invest in developing their most valuable resource (employees), who ultimately determine any organisations productivity and profitability, seems logical and essential (O'Donaghue A. 2001). Unlocking an individual employee's potential creativity, skills, technical training, and ability to communicate effectively and timely, is believed to be the greatest opportunity for organisations to develop and improve long-term efficiencies. If untrained and unfairly treated, employees are less likely to perform to their full potential (Gupta A. and Thomas G. 2001), (Linowes J.G. 1999) and (Swe V. and Kleiner B.H. 1998). Yet, to ensure efficient and continued use of a new ICT system, trainers need to (simultaneously) consider the possible negative effects associated with training potential end users (Vickers M.H. 1999). These include:

- fear and stress of employees (old and young) having to learn an unfamiliar / automated process; and
- impact on their self-esteem and ability to succeed (threatened confidence).

The necessity to recognise the culture of an organisation and its effect on training (and its evaluation) is essential. Trainers are to consider the following 'action points' to help address this issue (Lewis P. and Thornhill A. 1994):

- firstly, attempt to understand the organisation's culture and organisational attitudes to training evaluation;
- recognise all levels of the organisation's culture in order to consider how positive attitudes can be fostered at all of these;
- determine measurable goals for changing attitudes to training in the organisation in relation to time;
- utilise (amongst other things) Table 8-6 to analyse the extent of the problem, the task to be undertaken, and how to bring about change;
- adopt a proactive approach to the advancement of organisational-level training and evaluation by 'promoting' this to senior management and by forging links with line managers and other key players in order to effect new organisational 'beliefs';
- choose a suitable change strategy or strategies to promote these new organisational beliefs (e.g.: through seeking answers to the critical questions in (Section: 8.10);
- involve a wide range of organisational participants in the implementation stage of the attempt to change attitudes; and lastly
- actively evaluate the results of this culture change attempt.

8.12.1 e-Training

The previously slow, jerky and mono-functional Web-based video conferencing technologies has been superseded by innovative synchronised and instructor-led training systems with video, audio and graphical presentations allowing fuller learning participation from any location. Furthermore, it is predicted that higher quality online training and courseware (meeting the ever-broadening needs of industry learners and organisations) will become standard methods of training and as a result alter the adult learning experience in future decades (Kilby T. 2001).

8.13 e-Security

The central concern industry organisations have in using the Internet; extranet, etc. (for information transfer between themselves), is that of security (Smith B.L. and Scherer W.T. 1999). Information security (e-Security) is about protecting those assets (Cabrera A., Cabrera E.F. et al. 2001). Therefore, information security and data protection complement each other (high-quality data protection implies high-quality information security), even though considered different – i.e.: data security is an important part of data protection, where as information security focuses on personal data. Yet, determining how to make data safe is only one aspect of e-Security. Equally important are ensuring the quality and accessibility of the data. (Cabrera A., Cabrera E.F. et al. 2001) refers to 'three information security model elements':

- **Confidentiality**: ensuring that information is available only to those who are authorised or entitled to see it;
- **Integrity**: ensuring that the information is accurate, complete and not corrupted; and
- **Availability**: ensuring that the information is accessible when required.

Interestingly, the industry's trust seems to be 'more biased' to telephone calls than to transferring documentation or information electronically (e.g.: email, Internet, etc.), yet (in basic terms) no more (or less) secure than the conventional telephone call – i.e.: email messages are routed between Internet service providers, over public telephone networks (Anumba C.J. and Ruikar K. 2002).

IIB Guide (IIB 2002) identifies Australia (Queensland in particular) as leaders in e-Security research and development capabilities, including:

- largest e-Security research community in the southern hemisphere;
- second largest cluster of e-Security companies in the world;
- supported by world class research infrastructure;
- highly skilled e-Security workforce;
- low operating costs, low taxes, low cost of living and low cost of conducting e-Security research;
- close proximity to Asia-Pacific markets
- high availability of multilingual workforce;
- globally competitive; and

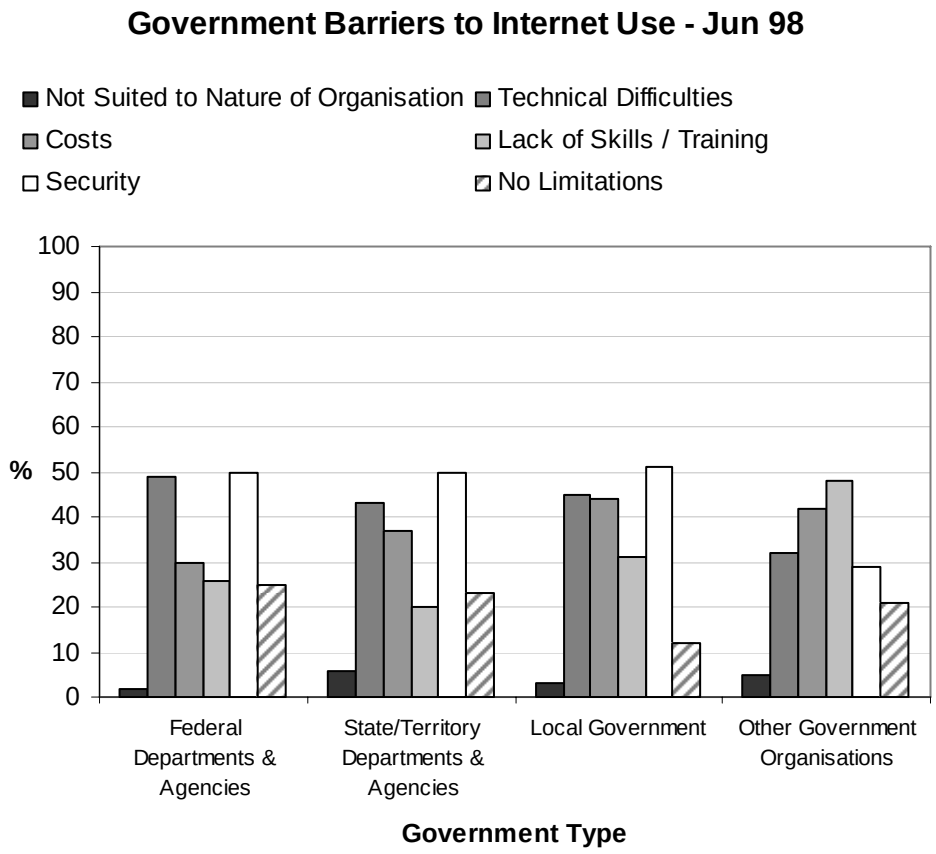
8.14 Government Barriers of Internet Use

This section covers the Australian Government's IT and Internet activities for periods 1997-98 (ABS 1999). The 1999 - 2000 issue of ABS Catalogue No. 8119.0 - Government Use of Information Technology (released 28 May 2002) is not referred to in this document as it only covers the Australian Government's IT&T Expenditure and IT Employment for that period.

Referring to Figure 8-11:

- Of those government organisations with access to the Internet (June 1998) - 43% reported 'security concerns' as a limitation to greater use of the Internet.
- Identifying 'security concerns' as a limitation was similar for:
  - Federal (50%);
  - State/Territory (50%); and
  - Local government (51%).
- Other limitations identified by government organisations included:
  - 'technical difficulties' and 'costs' (both 40%);
  - 'lack of skills or appropriate training' (33%); and
  - 'not suited to the nature of the organisation' (4%).
- Only 19% of government organisations with Internet access identified 'no limitations'.
- Of government organisations (1–99 employees):
  - 39% reported 'lack of skills or appropriate training' as a barrier to greater use of the Internet;
  - 37% reported 'costs';
  - 31% reported 'technical difficulties'; and
  - 27% reported 'security concerns'.
- In contrast, for government organisations (1000 or more employees):
  - 76% reported 'security concerns' as a barrier to greater use;
  - 66% reported 'technical difficulties';
  - 45% reported 'costs'; and
  - only 25% reported 'lack of skills or appropriate training' (ABS 1999).

Figure 8-11: Government Barriers to Internet Use



9 FUTURE TRENDS AND RECOMMENDATIONS

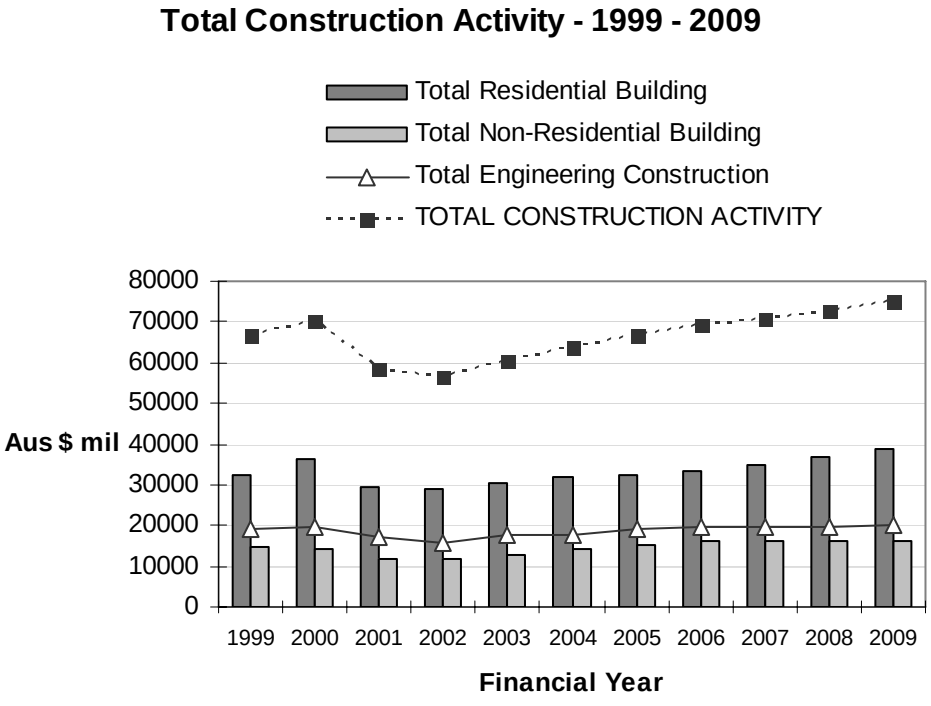
9.1 Construction Industry

The construction industry has always excelled at managing complex programmes, often involving groups of people necessarily brought together for one-off projects and working in hazardous or inhospitable places. As a result, the industry has developed both flexibility and good skills in problem solving. What it is not so good at, however, is planning for the future (Foresight 2000).

For sustained business growth, people in the construction industry need to plan. To do so they must have access to strategic information. With projections of industry activity, industry organisations can make informed decisions and respond to future challenges. Industry people rarely have time to analyse (in depth) the economic, technological and social conditions, or the changes influencing the conditions in which their businesses operate. For this reason, they need easy access to information indicating future levels of industry activity and industry trends (APCC 2001).

The predictions in Figure 9-1 are designed to help people in all parts of the industry improve their business planning for 3 to 5 years into the future (1999 – 2009 financial years) – i.e.: when organisations are planning major investments and disposals (APCC 2001).

Figure 9-1: Total Construction Activity – Australia: 1999-2009



Although the industry is described as 'cyclic', the underlying trend is one of growth. Yet, according to (APCC 2001), these changes do not alter the general trends for the industry over the forecast period. Referring to Figure 9-1:

- Total construction expenditure reached its highest level ever at $70.2 billion in 2000.
- Significantly lower levels of work were expected for 2001 ($58.4 billion) and 2002 ($56.7 billion).

- Following the 2001-2002 decline, seven years of increasing construction activity are forecast with the 2009 level short forecast $75.1 billion.
- The low point of the current cycle ($56.7 billion in 2002) is $12.2 billion higher than the low point of the previous cycle ($44.5 billion in 1992) and $12.9 billion higher than the low point of the cycle before that ($43.8 billion in 1983 and 1984).
- The low point in 2002 is also higher than the total expenditure in any year before 1998.
- Figures for previous cycles have been adjusted to the same base to enable meaningful comparisons to be made.
- For the period 2003 to 2008, slightly higher annual levels of activity are now expected.
- The forecasts for 2009 have been reduced by $0.6 billion.

Australia's total construction industry predictions in Figure 9-1 are derived from a more detailed prediction of industry sector activities and can be viewed in Figure 9-2, Figure 9-3 and Figure 9-4.

Figure 9-2: Total Residential Building Activity – Australia: 1999-2009

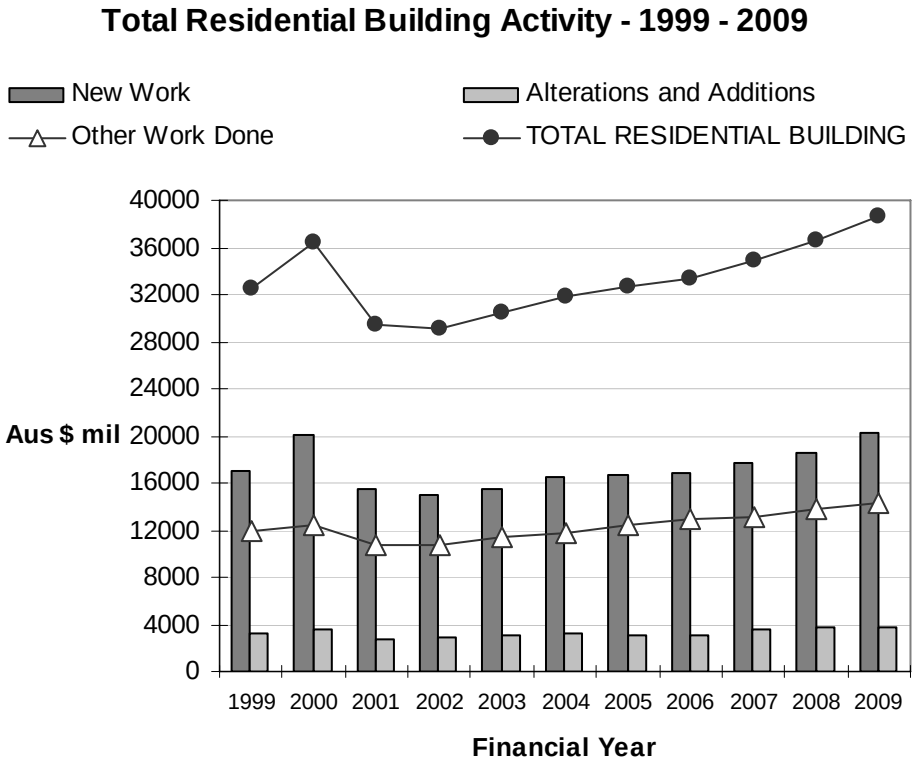


Figure 9-3: Total Non-Residential Building Activity – Australia: 1999-2009

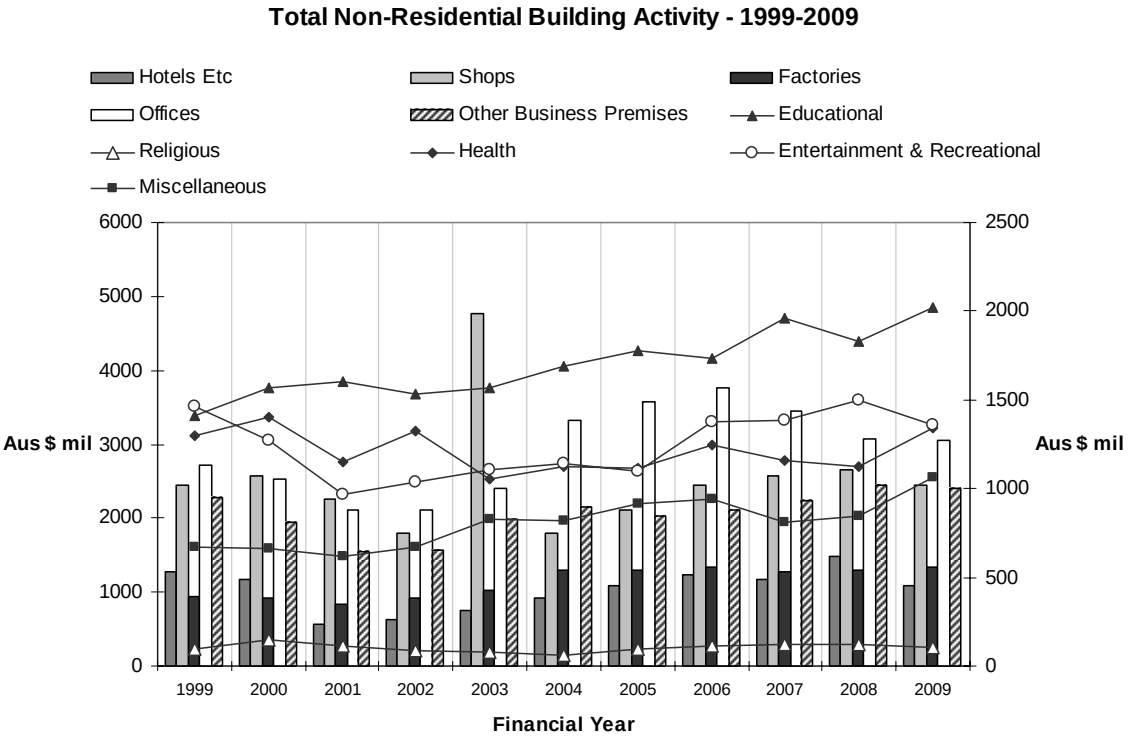
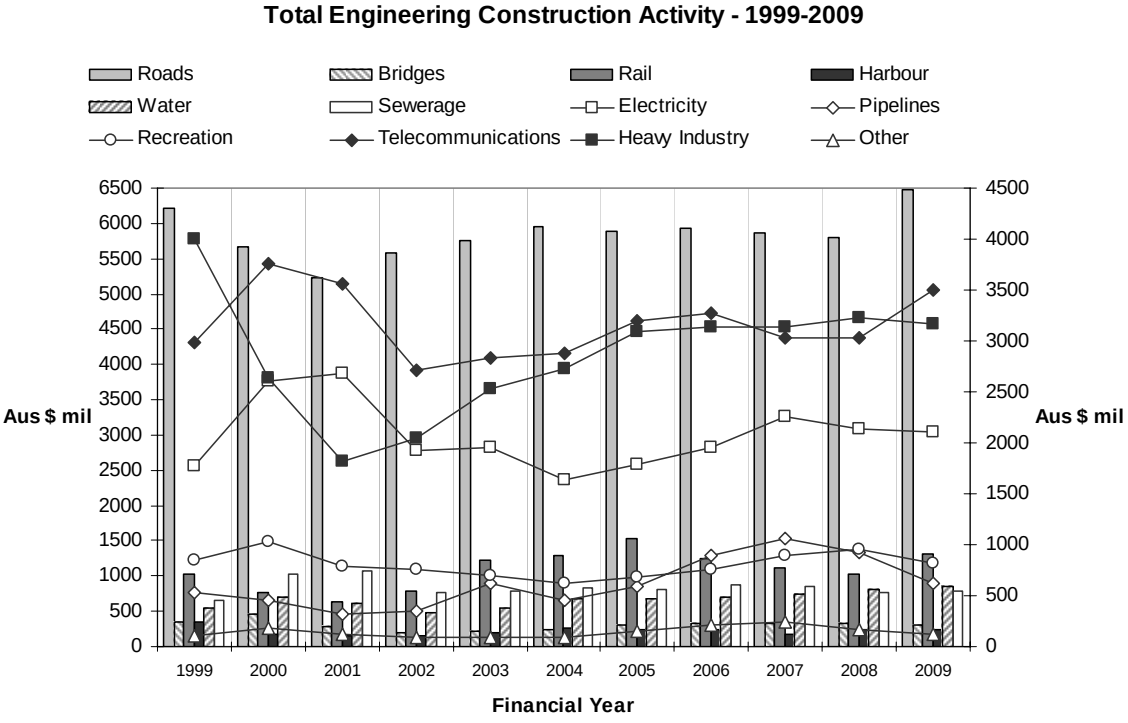


Figure 9-4: Total Engineering Construction Activity – Australia: 1999-2009



By helping people understand the likely trends and levels of future activity within the main segments of the construction industry, businesses should be better equipped to anticipate future work in their areas of interest and help people address questions like (APCC 2001):

- What is likely to happen to my sector of the industry?
- Is my current area of business, or the area of business I want to be in, likely to expand, contract or stay still over the next few years?
- If it is expanding, what are my options and what do I want to do — short term (6–12 months), medium term (12 months – 3 years), or long term (3–5 years)?
- Do I want to expand my business to match?
- Do I want to specialise or expand into new areas?
- If my sector of the industry is contracting, what are my options and what do I want to do
  - short term (6–12 months);
  - medium term (12 months – 3 years); or
  - long term (3–5 years)?
- Can I diversify?
- Should I delay plans to expand or buy new equipment (e.g.: ICT tool / system)?
- Should I buy new equipment (e.g.: ICT tool / system) now instead of next year so that I am better positioned to compete in a contracting market?
- Where will the future opportunities for my business be?
  - Near home, regionally or in my state?
  - In another state?
  - Overseas?
- What employees and skills will I need in the short, medium and longer term?
- Do I have the necessary skills or should I be looking to train existing employees and/or recruit new employees with the necessary skills?

There is a ‘perceived fear’ of ‘exploitation’ of technology-led innovations. Industry practitioners are to be convinced of supportive terms and conditions of contract do not lead to exploitation (removal of fear). Industry recommendations include (CRISP 2000):

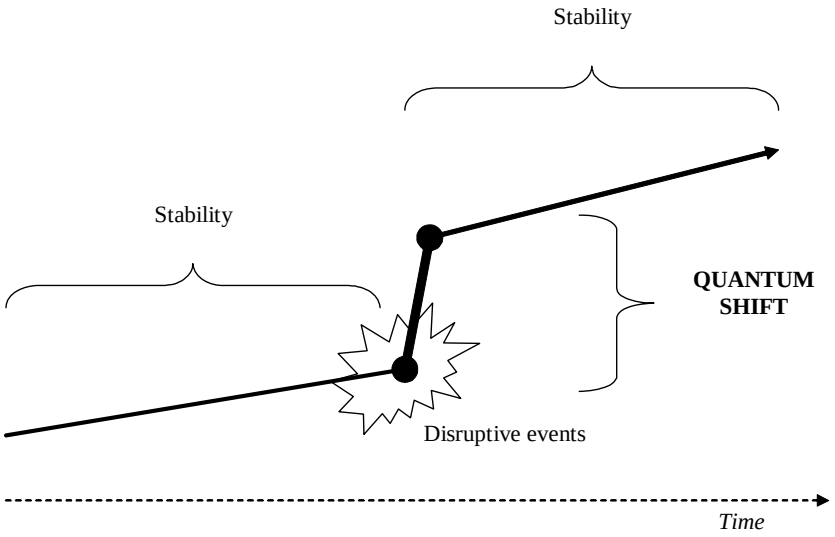
- The creation of common understanding would enable the construction industry to take positive action.
- Appropriate and easily accessible information on risk evaluation and implementation is needed.
- Both cultural and contractual changes are required to remove the constant fear of liability and the concern to assign blame to individuals and organisations.
- This would create an environment that is receptive to ideas, challenges and opportunities.
- It would also enable the investigation of unsuccessful projects to provide lessons for the future.
- Additionally, there is a need to lessen constraints imposed by regulations, codes and standards that tend to oppose novel solutions.

9.2 Technological Change

At the beginning of the twentieth century, the ‘industrial era’ was born through a ‘quantum shift’ - from an agricultural to an industrial economy (Figure 9-5). As a result, original ways of working and techniques for managing complex organisations had to be changed, consequentially causing the rise and continuous improvement of mass production tools (efficiency) and classic management techniques ever since (Youngblood M.D. 2000):

- 1960s: Innovation - challenging the established norm;
- 1970s: industrial strife and conflict between employer and employee;
- 1980s: enterprise culture with strategic alliances and privatisations; and
- 1990s: short term contract, outsourcing, flexible workforce and a long ‘working hours’ culture (Cooper C.L. 1999).

Figure 9-5: Disruptive Events (Change) - Causing a 'Quantum Shift'



Today, the development of ICT can be compared to that of the industrial revolution, where the predictions of its impact on society are described as being 'bewildering and controversial' (Ahmad I. 2000). The success and survival of industry organisations will depend largely on how 'valuable' strategic principals are developed, adopted and acted upon in the wake of technological change or ICT 'revolution' and how the industry's contains its increased 'dependency' on the 'connectivity' of the Internet. As a result, some of the impacts facing industry organisations include:

- **Hectic pace:**
  New process innovations and product introductions have accelerated. Product life cycles are becoming shorter. New industries are emerging. What made a business successful may not keep it successful in the end. Sayings like '*Don't fix it if it isn't broke*' is changing to '*If you have been doing it the same way for the past 20 years, chances are you are not doing it right anymore*'
- **Increased productivity:**
  More work can be done in less time. The cost of time may go up as a result. Mistakes will get costly too. The demand for higher quality and 'zero defects' will increase. The traditional client-designer relationship may change. Clients will demand fast turn-around times, while designers will be competing among themselves for creative designs and quality products.
- **Legal infrastructure:**
  A new legal infrastructure for contracting and doing business using ICT and the Internet will have to evolve. Different standards and meanings will come into play in cyberspace regarding such issues as signatures, time stamping, intellectual property, privacy, liability, and jurisdiction.
- **Power of knowledge:**
  ICT education will somehow have to be incorporated as a supplement to technical knowledge and expertise in various fields. The workforce of the A/E/C industry will have to embrace the ideas of on-the-job education, continuing education, and part-time graduate study.
- **Creative destruction:**
  ICT and the Internet enable industry participants to bypass many business functions. Many '*reinventing-the-wheel*' type functions will become obsolete within the organisation as well as the industry. The demise of certain functions may give rise to uneasiness and resistance in the industry. Yet this phenomenon should be viewed as '*creative*

destruction,' since new and better ways of doing business are replacing old and unnecessary ones.

The above 'impacts' (due to technological change) are supported in (Gann D. 1997) with the following 'scenarios' in which new technologies (e.g. ICT) - coupled with significant organisational change and skills development - could improve performance characteristics of construction:

- **Production process (as a whole)**: the total process, current levels of inefficiencies and waste materials, could reduce labour and time, as well as pollution in half - by streamlining supply chains and through the introduction of better management practices. New ICT systems could improve performance and help integrate briefing and design decision-making and improve 'flexibility' to meet customer needs.
- **Output**: it is unlikely that construction output will increase. However, new construction activity could be stimulated (with additional investments made), if significant cost reductions can be achieved through technical and organisational change.
- **Employment**: technical (e.g.: ICT) innovation aimed at improving performance, is likely to have serious consequences for employment, training and recruitment.
- **Productivity**: when considering the total process (from initial client discussions to completion and operation of facilities) there is vast room for performance improvement (directly related to technical and managerial competence). Successful demonstration projects have illustrated major performance benefits through the implementation of new ICT systems (for coordination and control) together with component-based approaches in construction.
- **International competitiveness**: the development of further technical (and ICT) capabilities in international construction and consulting design and engineering firms could increase export markets.
- **Quality of products**: technical change in materials, components and systems integration could improve physical and aesthetic durability, and reduce embodied and life-cycle energy costs.
- **Cost and prices**: technology is one of a number of factors affecting construction prices. Unless these costs and prices are kept under control, construction is likely to loose support through substitution for other investment industries and commodities.

9.3 Paper to Electronic

Project communication is becoming increasingly complex. Research has shown the 'rapid transmission' of effective project information / communication is vital (key factor) to ensure project success and improved performance (Thorpe T. and Mead S. 2001) and (Olesen K. and Myers M.D. 1999). Current / traditional information and communication flows within the construction industry are mostly manual and hence slow (Anumba C.J. and Ruikar K. 2002):

- Producing numerous paper copies of documents and drawings.
- Management of 'loose' documents is often time-consuming and tedious.
- Library 'archives' of documents need to be maintained to effectively access data as and when required.
- The reliance on third parties, such as courier services, can lead to delays.
- The added expense incurred in the delivery of project documents to project members who are geographically distributed.

Today, even the number of e-mails transmitted and received in organisations is rapidly approaching the number of printed (paper) letters sent and received daily (Schelberg N.S. and Weinstein S.D. 1999):

- evolved to the point where graphics and text is virtually identical to the printed (paper) mailing;
- transmitted at a fraction of the cost of a printed version; and
- delivered widely and (almost) instantaneously to any location in the world.

To ensure the transition from paper to electronic will be successful, the industry needs to 'crawl before it attempts to walk' the ICT road of technological change (Zipf P.J. 2000). The skill lies in how businesses manage and transform information – i.e.: freedom of access and seamless interchange of shared information. Yet, standards for data exchange continue to be an issue in facilitating communications between different ICT platforms (Foresight 2000) and (Froese T. and Waugh L. 1991).

Finally, the introduction of advanced innovative technologies may allow the old (traditional) and new (ICT) practices to co-exist (for a short period) within any industry organisation, but will (eventually) lead to reorientation of the organisation (structure, processes and culture) (Palmer I., Dunford R. et al. 2001).

9.4 Competitive Drive

The current competitive drive of the industry is that firms adopt ICT as a 'necessity to drive costs down' (Fujitsu Centre 1998). The gap between the current use and potential of the technology indicates that these competitive 'dynamics' will continue for the near future. The industry has the opportunity to alleviate some of these effects by:

- successfully becoming a world leader through the use of ICT;
- learning how to transform its organisations, reconfigure the supply chain, and deliver new, improved and qualitatively different services and products (based on local and overseas market trends).

Furthermore, if the industry continues to explore the competitive 'dynamics' without exploring cross-sector potentials (Section: 6.4):

- limits its opportunity to internationalise – expand into overseas markets; and
- international firms will successfully enter the Australian market.

9.5 Virtual teams

There are two possible explanations for the limited research on virtual teams (Furst S., Blackburn R. et al. 1999):

- First - temporal: virtual teams are a relatively new concept; and
- Second - theoretical: it may be that managers, researchers and academicians do not yet appreciate that working in a virtual environment. Therefore may require different approaches from working in the traditional organisational environment.

Research recommends the implementation of (a previously developed) model of group effectiveness – i.e.: applicable to (Furst S., Blackburn R. et al. 1999):

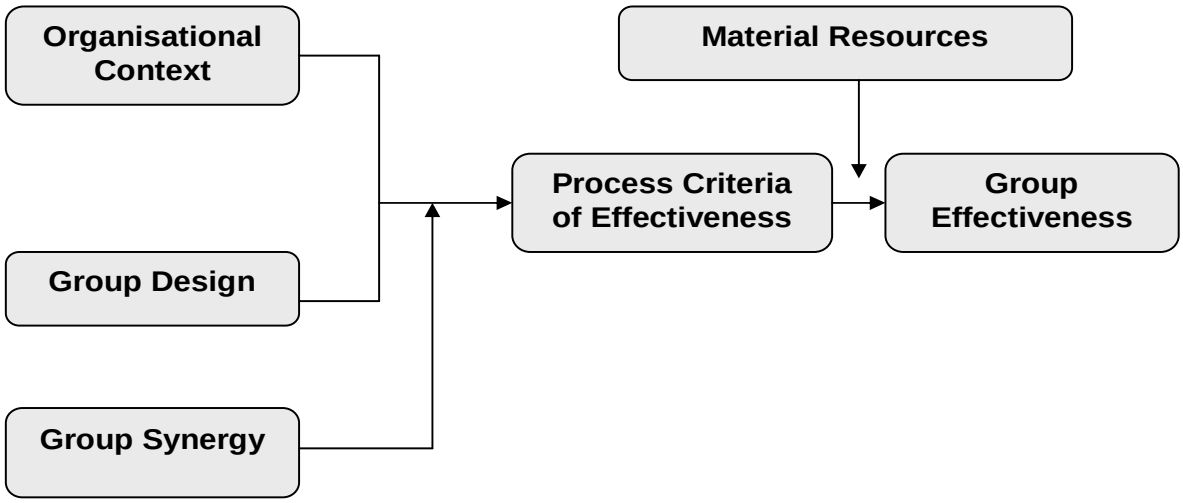
- the virtual environment; and
- that takes into account the differences between groups and teams as well as between co-located and virtual environments.

The Group Effectiveness Model (

Figure 9-6), consists of three factors:

- The degree to which the group's products or services meet the standards of quantity, quality and timeliness of those who receive, review and/or use the output;
- The degree to which the group's work processes enhance the capability of members to work together interdependently in the future; and
- The degree to which the group's experience, contributes to the growth and personal wellbeing of team members.

Figure 9-6: Model of Group Effectiveness



Finally, based on

Figure 9-6, (Furst S., Blackburn R. et al. 1999) propose a set of research questions (Appendix C) in an attempt to advance future research interests on effective virtual teams – i.e.: '*what has been or should be the nature of research into the causes of effective virtual teams'*: further suggesting that once these are answered, theoretical models for understanding, explaining and controlling virtual team performance will emerge, leading to even more incisive research questions. This initial investigation of virtual teams also suggests that benefits should accrue to both researchers and industry practitioners by combining ideas from organisational behaviour and human resource management with those from ICT.

'*We know a great deal about the technical aspects of being virtual. We now need to know more about making the human and teams, more virtuous*' (Furst S., Blackburn R. et al. 1999).

9.6 Improved ICT Implementation / Application and Commitment to Change

The decline or success of any company may bring about a change of strategy towards increased ICT integration. However, business success alone is insufficient for managers to justify the implementation of integrated ICT strategies unless there is a strong support for such change from ICT champions (preferably senior management) within the organisation. An organisation pursuing technological advancement, motivated only by profit maximisation (or other desirable financial objectives) is not enough. Many firms adopt ICT tools and systems for profit-motivated reasons and fail due to underestimating the difficult task of managing its impact upon organisation structures and cultures – i.e.: successful ICT adoption depends on the 'politics of technology' in its management in the organisation (Tantoush T. and Clegg S. 2001).

By investigating the practical ('real life') issues of successfully integrating a new technology into the geographically dispersed Canadian health system, five 'key issues' for successful ICT implementation were identified: (Jennett P.A. and Andruchuk K. 2001)

- Readiness of the environment: the more prepared the environment, the more likely successful implementation will occur – i.e.: upfront recognition of: workstation and ICT standards (professional and technical); training requirements; ICT champions and onsite coordinators; hardware and software planning; as well as human requirements.
- Analysis, strategic business plans and diverse partnerships: lessons learned and recorded experiences in academic literature need to be examined prior to implementation. Additionally, sustainability and accountability issues need to be included in a business case reflecting upon the need for any reengineering or reorienting of routines or processes. Finally, any public sector, private sector, research, academic and other industry organisation partnerships are to be recognised for the project.
- Equipment and ICT vendors: the purchasing (budget restriction) of compatible hardware, software and ICT equipment (standards, interoperability, interconnectivity, etc); renovating any space; and choosing appropriate vendors (providing maintenance, replacement, accountability and training) is described as one of the more challenging and important implementation issues.
- Staged implementation (Section: 8.3): a gradual / staged implementation is recommended.
- Evaluation: research identifies the lack of evidence and evaluation results upon which to make implementation decisions, as a major impediment. Suggesting the compilation of a database on lessons learned (e.g.: reporting on ongoing evaluation at each stage of the implementation) and best practice recommendations, and sharing it with other industry members.

Note:
Although undertaken within the UK health sector, construction industry participants can channel any lessons learnt and recommendations provided by the above research, and apply them to current / future ICT implementation projects.

To increase and strengthen the process of realising IT adoption benefits, (Fujitsu Centre 1998) recommend:

- **Increasing awareness of, and skills to implement IT–based strategic change by:**
  - developing and distributing case studies and best practice in moving from automation to strategic transformation in the construction industry;
  - developing and running short courses for SMEs on capturing the benefits of IT management innovations; and
  - developing and supporting a web-based 'help desk' on current best practice and available support.
- **Restructuring the industry supply chain to leverage IT benefits by:**
  - commissioning an international comparative study of the impact of regulatory frameworks and effective inter-organisational IT systems on industry structures; and
  - develop tender guidelines for Commonwealth and State Government projects that encourage IT-enabled collaboration across the supply chain.
- **Supporting the database-centred approach by:**
  - providing support for the development of project-centred shared databases; and
  - supporting the development of standards enabling inter-operability.
- **Encouraging a performance-based, value-added focus for IT use in the industry by:**
  - establishing industry-wide awards for IT best practice;
  - supporting industry forums on the advantages of using IT for value-added as apposed to cost-minimising IT strategies; and
  - researching the contribution of regulatory changes to the adoption of IT-based value added strategies by the industry.

Furthermore, to increase the rate of technological adoption within the construction industry (Mitropoulos P. and Tatum C.B. 2000) suggests the following 'actions' are to be taken by its participants:

- Increase external requirements: where customers mandate the use of specific technologies;
- Create 'problems': when measuring the performance of work processes – identify problem areas and initiate change. One strategy is by setting high performance goals or 'artificial problems' to initiate change;
- Increase potential for competitive advantage: where construction customers consider the contractors technological capabilities as a criterion in selection;
- Increase technological opportunities: dictated by the understanding of its benefits, availability of resources and organisational capabilities;
- Closer cooperation between technology developers and contractors: required to develop technologies that address the contractors operational needs; and
- Reduce the contractor's initial costs and costs of failure: by all project participants sharing the costs, risks, and benefits of new technologies.

Finally, the following directions have been identified by in (APCC 2000) as being critical to the successful take up of IT in the construction industry:

- Maximise access to shared learning across the construction industry whilst using knowledge from other industries;
- Require information from suppliers in electronic form;
- Expecting electronic procurement to be used in all phases of project procurement and facilities management;
- Using advanced tendering systems which provide real time accessible information to all interested parties (speedier interaction);
- Driving process re-engineering through structural changes in procurement processes of governments;
- Working with industry to integrate IT through the entire supply chain;
- Facilitate the use of 'project Web sites';
- Manage the use of 'as-built' information;
- Capturing and sharing information to better understand lifecycle costing;
- Adopt systems to share information in a usable form; and
- Resolve issues including: design copyright, intellectual property rights, confidentiality and commercial advantage.

9.7 e-Commerce and Construction

The real impact of e-commerce is in delivering productivity and efficiency benefits through a transformation of business processes and forging savings along the value chains of industry sectors. However, e-Commerce is not only seen as a way of cutting costs, but as transforming business and creating new value chains. The challenges of implementing e-commerce are now better understood and estimates of potential benefits are becoming more realistic (APCC 2001):

- underpins productive growth in the economy;
- is more than 'simply putting up a website or implementing a system for electronic procurement';
- provides a company with the means to 'inject' greater efficiency into tasks, such as: data collection and data management; and
- frees up company resources to focus less on administrative processes and more on strategic activities.

Due to the eCommerce technology changing at a rapid and ever increasing pace, any future trends are difficult to predict. Yet, (Anumba C.J. and Ruikar K. 2002) suggests companies

will have to devise new measures and strategies to automate their current business processes (influencing both cultural and technical aspects), and incorporate e-Commerce applications in their day-to-day business processes. Further identifying the following future e-Commerce trends within the construction industry:

- **M-Commerce**: new research taken up to explore future opportunities in mobile electronic commerce (m-Commerce) based on today's ability to connect mobile devices - e.g.: mobile phones and Personal Digital Assistant (PDA).
- **Wireless communications (Bluetooth)**: with unlimited applications, such systems speed up the distribution of information and allow increased mobility - e.g.: remote located construction site personnel will be able to communicate, collect and distribute data/information electronically.
- **Ubiquitous computers**: endless possibilities for more office appliances to be connected to the Internet, communicating and making various transactions on behalf of people.
- **Agent based procurement goods and services**: due to a 'shift' from 'software-as-tool' to 'software-as-assistant' – i.e.: the user informs the software agent about various tasks to be performed and the software agent then acts (in a proactive manner) by accomplishing tasks such as: monitoring incoming mail, comparing construction material price lists, or organising / distributing agendas when users are not present.

Significant effort is involved in using technology to integrate trading relationships. It requires a commitment from business to work together on solutions that are technology 'neutral'. For e-commerce to be fully effective, emerging systems (such as m-Commerce) must integrate with established technologies - e.g.: the only e-Marketplaces that thrive in the future, will be those that integrate with a firm's existing 'back-end' systems. The main driver for e-Commerce to reach its full potential will be companies collaborating to develop whole-of-industry solutions and deliver shared benefits. To achieve this, companies will need to share their understanding of business information and workflow processes, and agree on how they can best automate their interchanges for efficiency. This will then free business resources to concentrate more on competitive issues such as product quality and price (APCC 2001).

9.8 Interoperability

The recent growth in private e-Marketplaces (operating within an industry sector) raises the issue of interoperability between different electronic exchanges – i.e.: to ensure seamless business performance across sectors. Future development of open standards will be a vital component to interoperable electronic exchanges and in attracting supplier communities, especially small firms, to participate broadly in e-Commerce (APCC 2001). The International Alliance for Interoperability (IAI) (http://www.sgo.com.au/iai-ac/) and the development (at an international level) of Industry Foundation Classes (IFCs) will greatly influence these developments.

9.9 e-Trends

Current e-Commerce trends within the construction industry include (Anumba C.J. and Ruikar K. 2002):

- **Company promotion**: Architects, designers, fabricators contractors and other members of the construction sector are using the Web to promote their companies and inform people about the services they have to offer.
- **Product promotion**: The Internet is used for increasing product sales through online promotion. Product promotion is done either through an independent Web site or through an online vendor.
- **e-Procurement through Web directories and search engines**: The Web can be used as a tool to procure or obtain information about construction related suppliers and their products. By entering keywords to search for a specific document or information

(including jobs, products, specifications and bidding processes), the search engine returns with a list of the documents / locations where the entered keywords were found.

- **Project management**: Websites designed to streamline the construction business process by looking into how the Internet can be used to improve and integrate the process of design and management of a construction project. Such a project management Website may yield several benefits to its users, including:
  - speeding up the process of communication between different parties involved in a construction project; and thus
  - avoid any unnecessary delays that are often a direct result of miscommunication.
- **Project collaboration**: Web-based project collaboration tools are used to facilitate online collaboration for project partners and other stakeholders, allowing them to communicate (exchange ideas, make comments, etc) in real time and from any location (defying the boundaries of time and geography).
- **Online tendering (e-Tender)**: The Internet has now made it possible to provide tendering information online along with project specifications.

Dramatic developments in the performance of ICTs, and the widespread 'explosion' of applications and future trends (based on these innovative technologies), are described as 'universally anticipated', and include (Simmonds P. and Clark J. 1999):

- Widespread use of simulation, including modelling and virtual reality, for more robust design and specification.
- Increased use of sensors and communications systems will reduce further the need for a worker at the point of process or manufacture, and for precise identification of faults.
- Robotics and computer-controlled automation will reduce further the need for people to perform dangerous or repetitive tasks.
- Rapid growth in at-a-distance transactions (B2B purchasing, electronic banking, Internet-based services and retailing, etc).
- Prompt growth in the volume of information and data available, both commercial data (e.g. flight schedules) and public records (e.g. government contracts on the web), will be allied with increased power (and precision) of search facilities.

Finally, e-Trend issues to consider during the decision-making process include (Foresight 2000):

- e-Business is here to stay and the 'open 'availability of essential information and data is important to facilitate on-line customer decision-making.
- Technology can bridge the traditional gap between design and production.
- Joined-up manufacturers, suppliers and off-site production can lead to greater resources for research and development into new products and processes.
- Industry standard models may enable automated information sharing across the entire value chain - from products to projects.
- It is essential for the construction industry to play an active part in setting the world standards that everyone will eventually need to use.
- Specialist contractors, suppliers, contractors and the design team will use web-based project portals to manage the project and its associated information.
- For an industry susceptible to adversarial approaches, the issue of trust in the supply chain will be critical.
- Greater operating effectiveness and supply-chain efficiency needs new skills and talent - attracted through better prospects and changed perceptions.

9.10 e-Solutions

Australia (Queensland in particular) has been identified as being globally price competitive, delivering world class e-Business solutions (with the highest level of authentication and encryption processes available to safeguard against the misuse of personal and business data transmitted over the internet) to a diverse range of local clients, including (IIB 2002):

- online transaction services;
- brokerage services;
- integrated infrastructure management;
- data warehousing;
- e-Business system and software development;
- internet applications and ASP services; and
- consulting services.

(Appendix D) provides a summary of products and services offered by a diverse range of e-commerce organisations (including contact details and website addresses). Briefly discussing the relevance each website has to SMEs and how each e-Commerce organisation could assist their specific information and business needs (DCITA 1998).

Finally, the IIB Guide (IIB 2002) identifies Australian companies (Queensland in particular) as companies delivering world class / innovative ICT solutions for building and construction projects around the world, including:

- Construction project client management systems;
- Supply chain and Accounting packages for the building industry;
- Civil engineering applications; and
- Advanced digital design and exhibition displays.

Business partners or 'world-class' ICT solution providers can be found at www.iib.qld.gov.au/guide

9.11 e-Security

Legislatures are identified as typically ‘lagging’ behind technical innovation and social change (Woulds J. 1997). The successful implementation of ICT tools and systems (especially Internet-based) within the industry, are susceptible to the current legal status regarding electronic transmissions, use of electronic signatures, etc. Commitment by both government and industry sectors is required to help develop more innovative strategies to build a stronger and more competitive construction industry. Current legal investigations (Electronic Transactions Act 2001) must continue, aimed at strengthening organisational and individual use of electronic communications on projects, and thereby provide better management of communication risks such as:

- **Authenticity**: This concerns the source of the communication - does it come from the apparent author?
- **Integrity**: Whether or not the communication received is the same as that sent - has it been altered either in transmission or in storage?
- **Confidentiality**: Controlling the disclosure of and access to the information contained in the communication.
- **Matters of evidence**: This concerns e-communications meeting current evidentiary requirements in a court of law, for example, a handwritten signature.
- **Matters of jurisdiction**: The electronic environment has no physical boundaries, unlike the physical or geographical boundaries of an individual state or country. This means that it may be uncertain which State’s or country’s laws will govern legal disputes about information placed on the Internet, or about commercial transactions made over the Internet.

9.12 Culture

(Love P.E.D., Tucker S.N. et al. 1996) states that a cultural change has to occur within the construction industry to help counteract the 'forces of change' (Section: 3.1), reinforcing the need for further research and monitoring of ICT development and its level of adoption within the construction industry. Ensuring that over time, all project stakeholders will realise the benefits of changing existing / traditional organisational:

- behaviours;
- individuals;
- processes;
- structures; and
- tasks

A summary of 'effects' from implementing a reengineering process or technological change (e.g.: implementing a new ICT system) on four corporate culture 'tribes' (Appendix B-2) are revealed in Table 9-1 (Revenaugh D. L. 1994):

Table 9-1: Cultural Effects When Implementing a Technological Change

CORPORATE	
TRIBE	**EFFECTS WHEN IMPLEMENTING A TECHNOLOGICAL CHANGE**
Tough-guy / Macho	• The immediate feedback fosters a short-term perspective. • Does not support a strong planning orientation - lead to difficulty in implementing a reengineering process. • Speed, not endurance is often the focus. • Not taking an action, however, is as important as taking one. • Strong internal competition, which breeds individualism and weak communication.
Work hard - Play hard	• Action-oriented where success comes from its persistence. • Amount is more important than quality. • Listing the number of benefits of a reengineering process will foster more commitment than giving details on a few benefits. • Immediate benefits must be highlighted whenever possible.
Bet your company	• The ritual of the business meeting where important issues will get full discussion. • Decision making is top-down once all the inputs are in. • Actions are measured and deliberate. • Once the importance of a reengineering process is evident, specific decisions are made by top management and the plan starts becoming a reality. • Decision makers have a great deal of character and self-confidence, which should enhance good follow-through on decisions. • People become highly dependent on one another (never 'burn any bridges') - implying better-than-average co-operation and communication between departments during the implementation effort.
Process	• Policies and procedures are critical to a successful re-engineering effort. • Everything must be put into a memo and/or documented. • Job titles play an important role - therefore as new responsibilities are created or delegated, careful consideration should be given to job title and perceived status.

9.13 Training and Education

Construction organisations need to become learning organisations - attuned to absorbing and using knowledge and providing for lifelong learning. Investing in human capital, to bridge the skills gap, in research and development, and knowledge awareness, will help to maintain competitiveness. Within the next ten to twenty years, the construction industry will require a complete range of different skills. To meet these needs, a 're-think' in the way construction education is organised to deliver these skills is required, due to computer and ICT integration of construction processes, implying a need for 'cross-disciplinary education' (Foresight 2000).

There is also a significant role for tertiary education to develop and support the understanding of how to evaluate and implement technological change and innovation. This provision is required both in undergraduate / postgraduate courses to create a more receptive and able cadre of construction professionals (including the creation of a more common understanding) as well as the role of providing specific research and consultancy support to companies or networks (CRISP 2000).

Benefits to be gained from investing in improving the skills and knowledge of employees include (Foresight 2000):

- highly trained and motivated workers leading to more successful firms;
- better training will raise industry standards and improve employment prospects;
- a healthier and happier workforce;
- an improved image for the industry and attraction of more skilled people;
- research and development has long-term economic gains;
- an innovative environment that will stimulate and create more and better ideas;
- more flexible use of multi-skilled people; and finally
- a high-tech image delivering improved social benefits will make the industry more attractive as a career for young people.

9.14 Strategic, Technological and Project Innovation

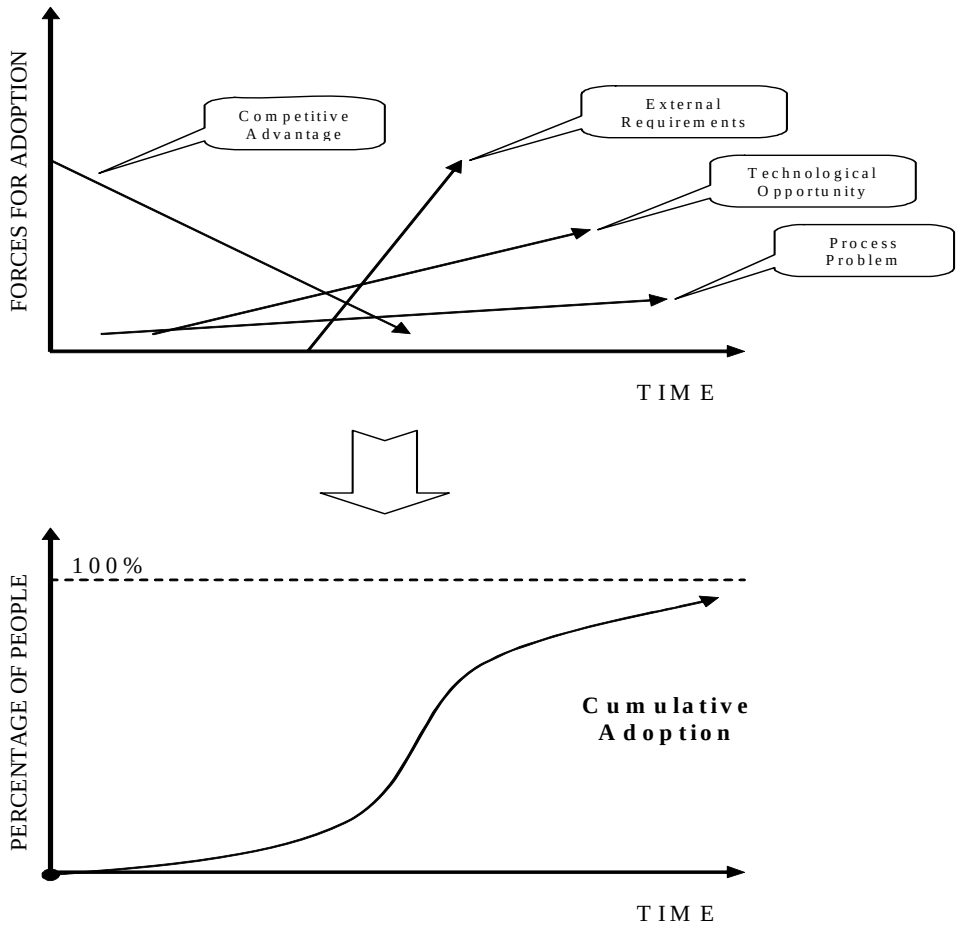
Due to the evaluation and decision-making process (regarding the adoption of a new technology) considered as being at the core of the innovation process, (Mitropoulos P. and Tatum C.B. 1999) recommends the following actions managers within construction industry organisations can take to increase the rate of technological innovation and the likelihood of success:

- **Strategic Innovation:**
  - Strategic technology assessment:
    Senior executives must identify and continuously monitor the ‘core’ technologies for the company – i.e.: technologies that directly affect the company’s ability to compete and meet customer needs.
  - Thorough technological specification and evaluation:
    In order to address the risks and maximise implementation success – not by solving all potential problems, but by understanding the operational needs and capabilities that the new technology creates, its effects on other interdependent organisational systems, and by identifying the major areas of potential implementation problems.
  - Senior management direct involvement:
    Senior executives are to have direct participation in the formulation, specification and evaluation of the technology. This ‘informed intuition’ provides the necessary confidence to make an adoption decision.
  - Implementation strategies:
    Ensuring the implementation process focuses on maximising on the likelihood of success and minimises the consequences of failure.
- **Project Level Innovation:**
  - Provide more solutions: increased innovation by increased technological solutions, opportunities, and ‘success stories made available to project personnel.
  - Provide implementation support from non-project budget: two positive effects will result from providing additional resources without burdening the project budget:
    - (a) shift the project managers focus from minimising cost and consequence of failure, to maximising the likelihood of success; and
    - (b) the company opens the door for technological implementation that may not be successful or ‘pay off’ on the first project. Any benefits should be tracked and lessons learned should be collected and disseminated for future implementations that are more successful.

- **Technology Level Innovation:**
  (Mitropoulos P. and Tatum C.B. 2000) discovered that 'innovative behaviours' and the 'diffusion rate' of a new technology, is driven (primarily) by (a) four industry conditions (Section: 7.1), and (b) organisational factors (sensitive to those conditions).

  Figure 9-7 illustrates an 'S-curve' resulting from the sum of the four forces, which in turn provides the following hypotheses for future research / testing:
  - At the early stages of technology diffusion, the primary reason for adoption is either competitive advantage or an important process problem.
  - Technological opportunity is low at the early phases - as the cost of technology may be high and the skills may not be available.
  - Process problems are assumed to increase over time:
    - as the companies grow;
    - project characteristics change; and
    - performance requirements increase.
  - External requirements typically do not exist in the early phases of a project but increase later as more competitors use the technology and customers require its use.

Figure 9-7: Innovative Drivers and Technological Diffusion

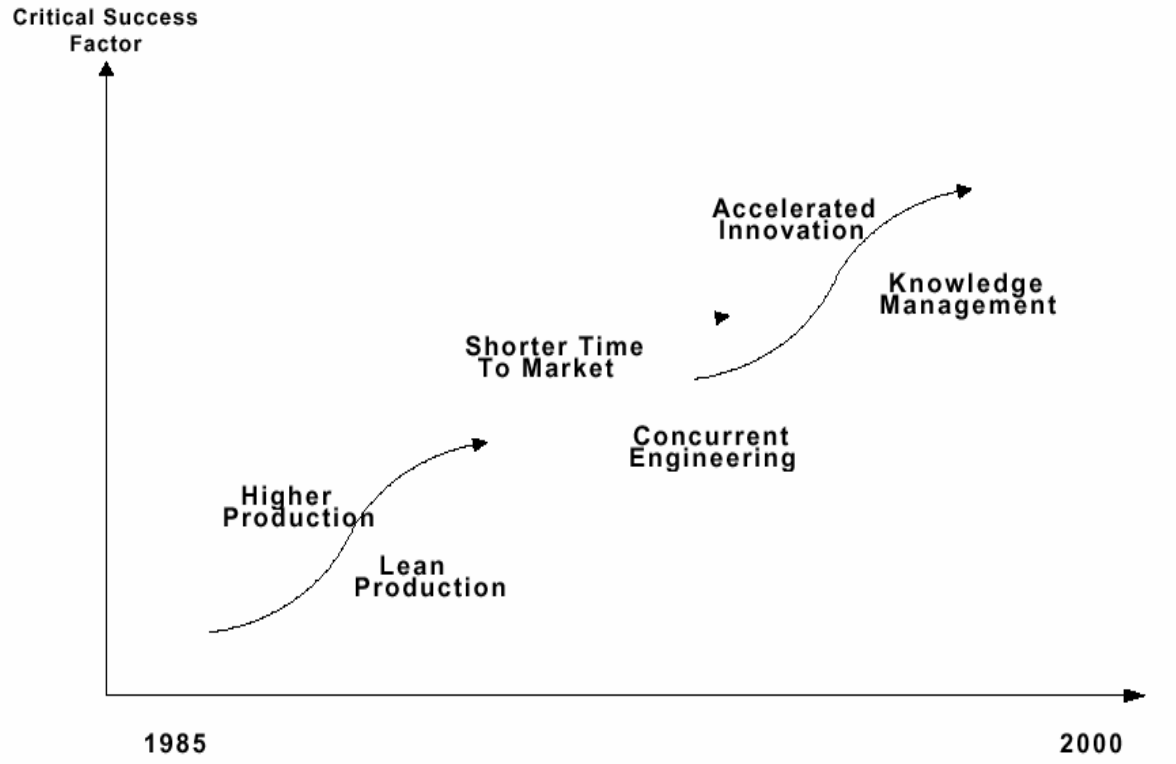


Extract from (Mitropoulos P. and Tatum C.B. 2000)

9.15 Innovation through Knowledge Management

Sharing and exploitation of knowledge is the key to development of new products and innovation. Innovation will not take place without good ideas, yet equally, not all ideas will create innovation. There is a need to bring together appropriate knowledge throughout the industry to generate lasting improvements. A key critical success factor for the future will not simply be improving production or reducing time to market, but accelerating innovation through 'knowledge management' (Figure 9-8) (CRISP 2000).

Figure 9-8: Industry Critical Success Factor – Knowledge Management



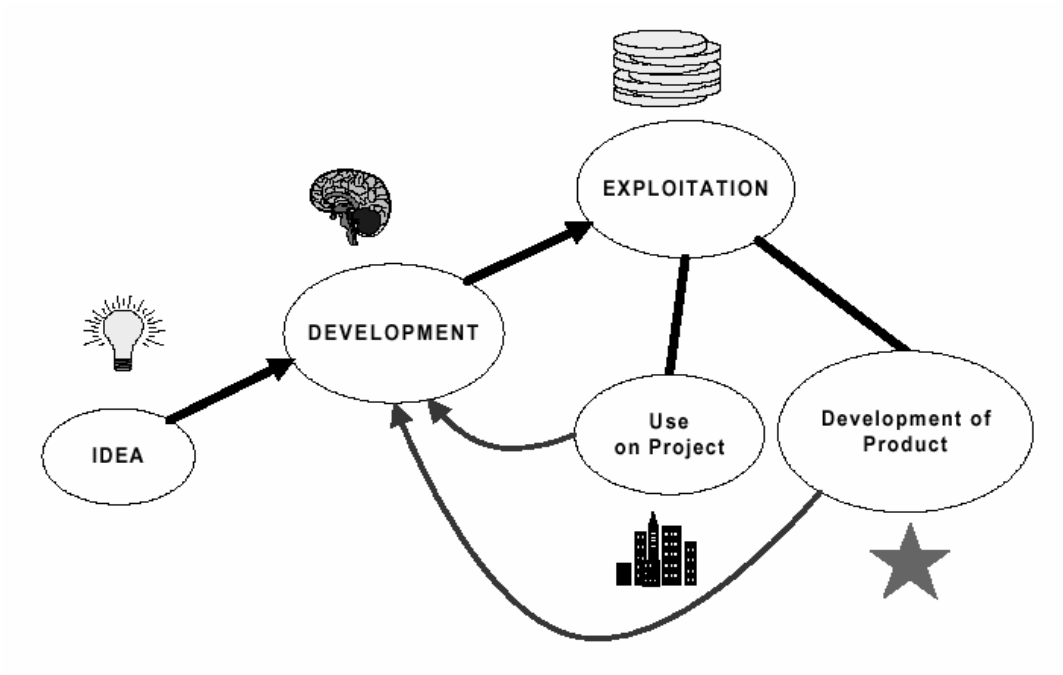
Extract from (CRISP 2000)

Furthermore, the construction industry must attempt to 'pull together' systems, values and behaviours, in order to create an infrastructure in which individuals may interact formally / informally, periodically / spontaneously, personally / electronically. Leverage of knowledge will be a key means of dealing with increased competition world-wide (CRISP 2000). This is difficult to implement in practice - as even the best ideas often have 'gaps' between:

- ideas and development;
- development and exploitation; or
- exploitation and feedback.

Therefore, in order to produce continuous improvements, careful consideration needs to be given as to how best to integrate the phases in Figure 9-9 (CRISP 2000).

Figure 9-9: Knowledge / Idea Development Process



Extract from (CRISP 2000)

9.16 Nanotechnology in Construction

Nanotechnology is not just a future technology – it is already with us. Its long-term prospects are immense, extremely varied and exciting (Bartholomew D. 2001). Although the construction industry has not been a major driver in nanotechnology, the industry is considered a 'significant beneficiary' - effecting / influencing it in many ways. Even with nanotechnology's role in the development of innovative of ICTs – i.e.: through developments including: mobile phones and CAD, and promises to change it further with integrated project data systems, Virtual Reality and electronic trading - there are numerous other products and social changes that could affect construction (Table 9-2):

Table 9-2: Nanotechnology in Construction

NANOTECHNOLOGY IN CONSTRUCTION	
DIRECT IMPACTS ON BUILDINGS, INFRASTRUCTURE AND THE CONSTRUCTION PROCESS	
Environmental monitoring sensors	Embedded in structures to monitor pollution, noise, temperatures and other factors important for health and safety. These will be autonomous, intelligent, often powered by ambient energy, able to store data internally for later interrogation or send it by radio to a base station, and increasingly affordable and widely used.
Performance monitoring sensors	Technically similar to the environmental monitoring sensors, but monitoring things like structural strain, vibration, and the operation and efficiency of HVAC plant.
Video cameras	Cheap and small enough to be used very widely for crime prevention, observing the flow of people and traffic, and for environmental and performance monitoring.
GPS	cheap and small enough for tagging materials and components in delivery and on site, and people
Materials and coatings	Stronger construction materials, more durable paints and other surface coatings, and surfaces with special (e.g. optical) properties

Photovoltaic cells	Economic enough to be widely used, either as separate components or as special surfaces on conventional components
Remotely-controlled devices	Enabling users to 'drive' many aspects of buildings from elsewhere
More sophisticated and accurate simulation-based design tools	Enabling buildings to be more energy efficient (passive buildings that moderate climate more effectively, services that perform better as systems) and structures to be built with smaller design margins (more elegant bridges).
INDIRECT IMPACTS CHANGING THE CONSTRUCTION MARKET	
Demographics	Because people will live longer
Health	fewer well people with functional disabilities
Healthcare buildings	More treatment in local centres, fewer large hospitals
Changing patterns of work	More videoconferencing, and more 'tele-working' and home offices; less office space, commuting and business travel
Renewable energy	More local (photovoltaic) electricity generation, so fewer power stations and less transmission infrastructure
More sophisticated control of road traffic	increasing road capacity
Changing forms of entertainment	'Experience centres' with wrap-round displays, fewer libraries.

The key breakthrough from nanotechnology-based products will usually be in size and affordability, leading to wider use of existing bulky and expensive devices (Bartholomew D. 2001).

9.17 Government

Governments play a central role in the promotion and support of technical (e.g.: ICT) development in construction, through instruments, such as (Gann D. 1997):

- **Skills and training policies:** industry could benefit from better construction skills; modernised training programs; and altered working practices (to develop the capability to working with new technologies).
- **Direct promotion and R&D funding:** applied research sponsored in collaboration with industry and research institutions through programs that provide matching funding.
- Procurement policies: governments remain major customers for construction goods, services, and projects (stimulating further performance improvements).
- **Regulatory policies:** governments have a 'duty' to 'protect' public interests. The use of appropriate regulations concerning the governance of technology will stimulate further performance improvements.
- **Trade policies:** the wide range of trade instruments that exist could be used to provide preferential support for the development and use of better construction technologies.

9.18 Research and Development (R&D)

Due to the nature of the industry (involving large numbers of geographically dispersed organisations and individuals), construction project communication activities are inevitably complex (Anumba C.J. and Ruikar K. 2002). Ongoing R&D efforts in determining ways to improve traditional (paper-based), tried and tested methods of communicating, carrying out business and managing construction projects (through the implementation and application of standard / off the shelf, custom-built and Internet-based ICT tools and systems within the construction industry), accentuates increased recognition of the potential opportunities and benefits these innovative technologies have to offer.

Unfortunately, when it comes to researching and developing innovative technologies, compared to other industries, the construction industry is said to be lagging (Michel H.L. 1998). This limited investment in R&D is due to (but not limited to):

- industry participants being fearful of any innovative ideas being taken from it and copied; and
- an 'overregulated' industry– due to '*one bad apple spoiling the barrel*'.

Arguably, the level of ICT adoption by the Australian construction industry appears to be neither more nor less advanced than that of our international competitors. Yet, current R&D efforts need to be increased in order to manage ongoing Industry implications and inevitability of ICT driven change (including its effect on organisational cultures / sub-cultures) (Black J.A. and Edwards S. 2000).

10 CONCLUSION

In this uncertain and ever changing world, the industry and its participants need to be creative, alert to opportunities, responsive to external stimulus, have a good grasp of the changing environment, and increase existing levels of confidence in its ability to adapt (Banks E. 1999). It is been over 40 years since the introduction of ICT tools and systems into the construction industry, yet organisations are still unable to obtain the many potential benefits of ICT investment - many years after the initial expenditures have been incurred. Furthermore, the industry has been identified as 'slow' in embracing innovative ICT tools and systems such as eCommerce, e-Conferencing, Internet and Intranets (Stewart R.A., Mohamed S. et al. 2002).

The acquired knowledge about ICT (and other) cultures is proven to be a valuable aid to industry organisations, managers and other participants who are charged with making effective use of ICT. Furthermore, organisations need to be aware of the larger 'patterns of interpretation' (develop out of its ICT policies) – e.g.: middle managers may be convinced of implementing an innovative ICT system and realise its importance to business needs, but may be confronted with dissatisfaction and unresponsiveness from senior management. Research suggests that all industry organisations recognise the difficulty of implementing change due to the 'persistence of enduring values and assumptions that are deeply rooted in human experience'. Cultures cannot be 'designed'. Cultures overlap, producing tensions of opportunity for gradual cultural and technical change. Although unable to effect such changes directly, organisations (management) need to adjust / revise formal ICT policies by implementing stricter controls over 'user initiatives' rather than maintain dominant values (Kaarst-Brown M.L. and Robey D. 1999).

With regard to e-Commerce, it will underpin further growth in the Australian economy as it enables innovation and significant advances in productivity and efficiency within and across industry sectors. While the continued development of e-Commerce is still widely recognised as a major 'dynamic' in business, there are signs that a more realistic understanding is emerging of how it will act to transform business. The e-Commerce market has seen significant changes over the last two years, focusing on moving beyond the technology and towards how these tools can make business processes and relationships more efficient. The underlying principles of doing business are proving to be just as important in the information age. The implementation challenges of e-Commerce are also more widely recognised. There is increasing evidence that companies can realise the benefits of e-Commerce by collaborating to work on whole-of-industry solutions and standards (APCC 2001).

The pace of change will be fast and all embracing. It will create more and greater business opportunities than ever before, both at home and overseas. It will be highly dependent on information sharing, customer-centric thinking, electronic commerce and co-operation at every level throughout an integrated supply chain. It will also embrace a changed cultural thinking that impacts on and benefits numerous aspects of the user environment (Foresight 2000).

In conclusion, in an attempt to improve industry communication and productivity, and increase ICT uptake within construction projects, Figure 10-1 and Table 10-1 provide an indication of how current and evolving ICTs can be applied within and between the various phases of project delivery – i.e.: from determining the needs of the client through brief development, design, construction and operation to disposal (APCC 2000).

Figure 10-1: ICT Use across the 10 Phases of a Construction Project

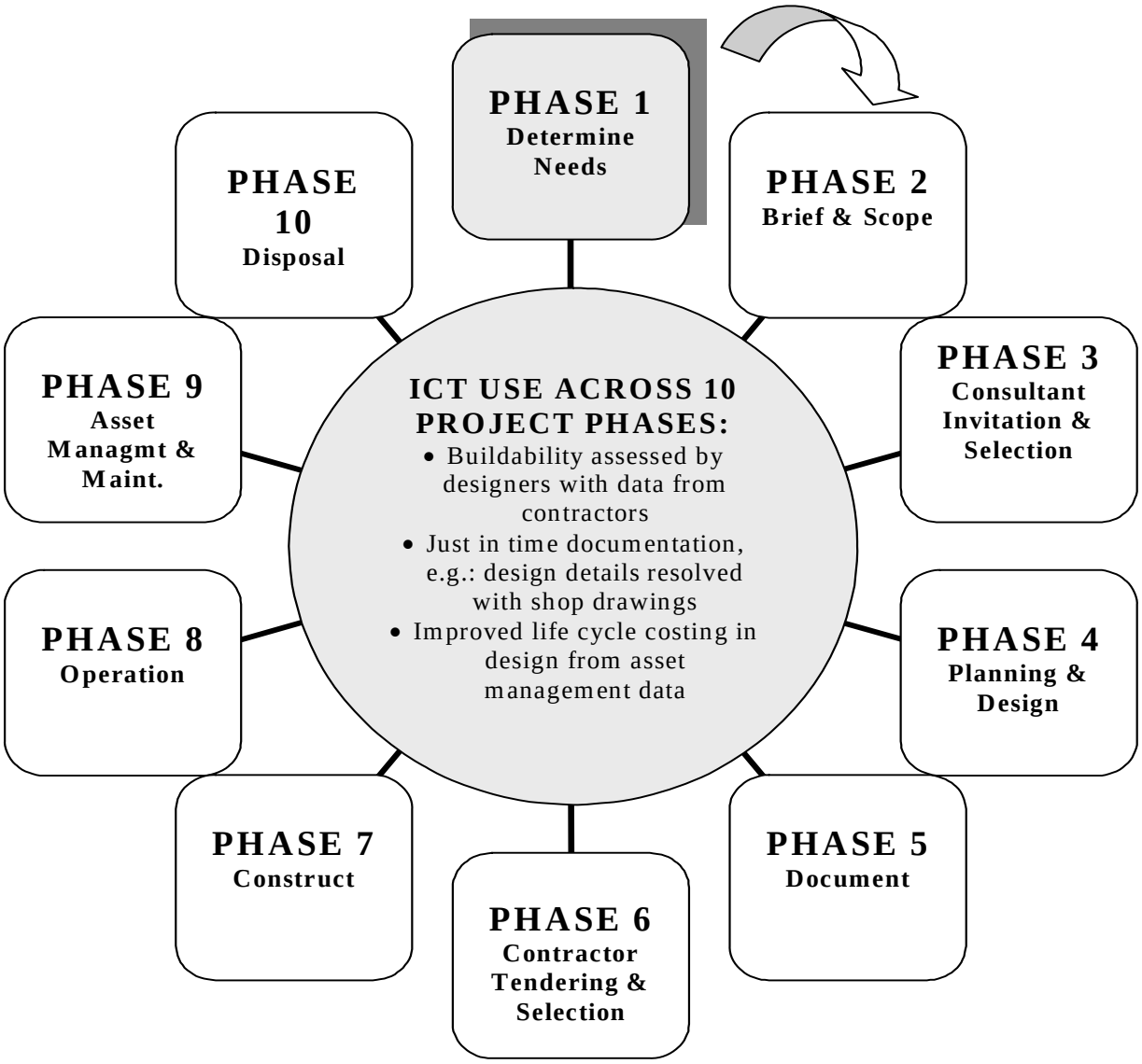


Table 10-1: Key to Figure 10-1

ICT USE ON A CONSTRUCTION PROJECT		
PHASE	**DESCRIPTION**	**APPLICATION**
1	**Determine Needs**	• Relevant information accessed electronically • Access internet examples • Analyse asset management data/historical data • Communicate by email • Commence formation of client database
2	**Brief and Scope**	• Access previous data • Electronic agreement, consultation and approval • Document assumptions and reasoning
3	**Consultant Invitation and Selection**	• Electronically bases prequalification (includes consultant updating records on line) • Electronic tendering
4	**Planning and Design**	• Electronic modelling • Check compliance with regulations electronically • Information exchanged between design team and client • Access to supplier / manufacturer information • Regulators have electronic access to client project database
5	**Documentation**	• Interactive electronically accessible data • Exchangeable / interoperable • Author only able to change - all other can use • Object orientated model with performance attributes • 3 or 4 / 5D modelling
6	**Contractor tendering and selection**	• Electronically based prequalification • Access to client database • Electronic tendering • Electronic tender analysis as a tool to aid selection (PQC) • Supply chain access to information • Electronic pricing within an organisation
7	**Construction**	• Virtual project office accessible to all stakeholders • Electronic payment • Electronic project management • Contract administration • Electronic variations and approvals • Document control/management
8	**Operation**	• Access to ‘as built’ information • Benchmarks based on real, accessible, electronically based data • Validation of project definition data
9	**Asset Management and Maintenance**	• Analysis of data across single project / multiple projects • Electronic project database provides basis for better decisions and models including financials • Electronic asset management plans • Condition assessment
10	**Disposal**	• Access to information for more effective recycling • Better information to determine point of time to dispose • Refurbishment data for selling on (widens scope for sale) – information has residual value • Hazard management

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12 GLOSSARY

For the purpose of this report, the following terminology definitions are used:

Table 12-1: Definitions

TERMINOLOGY	DEFINITION
Advanced electronic signatures	*Meets the following requirements* (Ecommerce 2002): • *uniquely linked to the signatory;* • *capable of identifying the signature;* • *created using means that the signatory can maintain under his or her sole control; and* • *linked to the data to which it relates in such a manner that any subsequent change of the data is detectable.*
Bluetooth	*Form of wireless technology that will remove the need for cables connecting computer equipment. It operates by means of low-cost short-range radio links that can be between mobile and stationary PCs, mobile phones and other peripheral devices* (Anumba C.J. and Ruikar K. 2002).
Construction Project	*Complex activity and team effort involving several participants (including client, architect, structural engineer, fabricator and engineer), as well as numerous inter-organisational activities and dialogue* (Anumba C.J. and Ruikar K. 2002).
Construction	*A process rather than an industry, with activities (including design, constructing, maintaining and adapting the built environment). Involving a multitude of organisations from a range of different industrial sectors, working together in temporary coalitions on project specific tasks (including design, engineering, supply and integration, erection and installation of a diverse array of materials, components and increasingly complex systems)* (Gann D. 1997).
Digital signatures	*Form of electronic signatures, based on 'public key' cryptography* (Ecommerce 2002).
ECommerce	*Can simply be defined as doing business by electronic means, typically over the Internet (Anumba C.J. and Ruikar K. 2002).*
Electronic mail (email)	*The exchange of computer-stored messages using telecommunication equipment. Although the body of messages are encoded in ASCII text, one can send non-text files, such as graphic images and sound files, as attachments in binary streams. Email was one of the first uses of the Internet and is still the most popular single use. Email can be exchanged between users of online services and people on local or wide area networks, other than the Internet. Email can be sent to lists of people and to individuals who have an interest in a subject (as long as they have asked or given their permission to put their names on the list)* (DCITA 1998).
Electronic Signatures	*Data in electronic form which are attached to (or logically associated with) other electronic data and which serves as a method of authentication (Ecommerce 2002).*
Extranet	*A relatively new concept yet rapidly becoming one of the industry's more visible technologies of the future. Defined by* (Smith B.L. and Scherer W.T. 1999) as*: a dynamic wide area network that links several different organisations, with a means of sharing information.*
Information System (IS)	*A system that: collects, records, stores and arranges data in the form of information* (Claver E., Llopis J. et al. 2001).
Information Technology (IT)	*The technical component of an IS as it includes: hardware, databases, software networks and other resources suitable for information processing* (Claver E., Llopis J. et al. 2001).
Information Technology and Telecommunications (IT&T)	*Services and technologies that enable information to be accessed, stored, processed, transformed, manipulated and disseminated, including the transmission or communication of voice and/or data, over a variety of transmission media. Transmission media include telephone, facsimile, Internet, data lines, satellite, microwave, radio, etc.* (ABS 1999).
Internet - 'the Net'	*Redundant network and path independent method of transmitting data - originally designed by the US Defence Department. Its original intent was to develop a network that would remain functional even in the event of nuclear war. Today, the Internet is a worldwide network of computers that facilitates data communication services such as remote login, file transfer, electronic mail, newsgroups and the World Wide Web* (DCITA 1998)

Interoperability	*The exchange of information between separate computer programs without the loss of content or meaning* (Yum K. and Drogemuller R.M. 2000)
Intranet	'*Organisational Internets*' or *the application of Internet Technologies (WWW) that link an organisation's computers thereby allowing them to share and access information from common server computers* (Schelberg N.S. and Weinstein S.D. 1999) and (Damsgaard J. and Scheepers R. 1999).
Geographic Information Systems (GIS)	*A computer based system (that incorporates CAD functionality) for storing, integrating, analysing and displaying data with spatial reference to the earth* (Zipf P.J. 2000)
Nanotechnology	*Nanotechnologies offer more for less: smaller, cheaper, lighter, faster devices with greater functionality, using less energy and materials. Concerned with objects and materials where dimensions and tolerances in the range 0.1–100 nanometres (10^{-9} metres) are critical. To put this into perspective, a hand is about 100mm wide, an integrated circuit typically 10mm across, a grain of sand 1mm, a hair less than 0.1mm diameter, micro machines around 1mm across (with components 0.1mm and less across), a transistor on a chip a few microns (10^{-6} metres, or 10^{-3}mm), a smoke particle around 1 micron, the DNA molecule 2nm across, and atoms around 1nm* (Bartholomew D. 2001).
Organisational Culture	*A set of values, symbols and rituals shared by members of a specific firm (sub-cultures* (Lewis P. and Thornhill A. 1994)*), which describes the way things are done in an organisation in order to solve both internal management problems and those related to customers, suppliers and the environment* (Claver E., Llopis J. et al. 2001).
Process Re-engineering	*The fundamental rethinking and radical design of business processes to achieve dramatic performance improvements in critical and contemporary measures of performance such as cost, quality, service, and speed* (Love P.E.D. 1996).
SME	*Small to Medium Enterprises:* • *micro enterprises (those which employ 1-3 people),* • *small enterprises (those which employ up to 20 people if in the services industries or up to 100 in manufacturing industry), and* • *medium enterprises (those which employ up to 500 people)* (DCITA 1998).
World Wide Web (the web or 'WWW')	*A global hypertext system that uses the Internet as its transport mechanism. In a hypertext system, one navigates by clicking hyperlinks, which can call up another document, a graphic image or a sound file. The links can be to files on the same computer, or on a computer on the other side of the world. The web was conceived in 1989 when Tim Berners-Lee proposed the development of a system that would enable scientists to browse each other's papers, to the European Particle Physics Laboratory (CERN) in Switzerland. The language and protocol he developed led to the World Wide Web known today* (DCITA 1998).

13 APPENDICES

Appendix A: ABS Survey Comparisons

The following points should be noted when comparing ABS surveys with the following international surveys (ABS 2002):

1. The **reference periods** of the surveys differ, with the Australian survey period being 6 months later than the surveys of Canada, the Nordic countries and the UK.
2. The **Canadian** and Australian surveys have a slightly different scope. Canada excludes enterprises in the Agriculture and Construction industries. Australia excludes Agriculture, forestry and fishing and (private) Education. The two countries both exclude very small businesses from their surveys but use different exclusion criteria. Whilst Australia excludes almost all non-employing businesses, Canada includes non-employers but excludes all businesses with a gross business income under $150,000 or $250,000 depending on the industry. It is thought that the impact of scope differences will be small at the level at which statistics have been presented in this publication.
3. The Australian scope differs from the common scope of the **Nordic countries**. In the comparison shown in Chapter 5, Australian data have been amended to (reasonably) conform to the Nordic common scope. Adjustments made to Australian data are to exclude information in respect of the Mining, Electricity, gas and water and Construction industries and to exclude data for all businesses with fewer than 10 employees. Even with those adjustments, there are some scope differences remaining. However, an analysis of Australian data indicates that the net effect of these remaining differences is unlikely to be more than 1 or 2 percentage points.
4. The **UK** and Australian surveys also differ in scope. The UK survey excludes the Mining, Electricity, gas and water and Construction industries and does not survey firms with fewer than 10 employees. In addition, the UK treats the Finance sector differently to the Australian treatment. In the comparison presented in Chapter 5, Australian data have been adjusted to the same scope basis as the UK, with both datasets excluding the Finance sector.
5. The **income concept used in the Canadian** and Australian surveys differs slightly. Canada compares the value of gross Internet sales (of goods or services belonging to and sold by the reporting business) with total operating revenue. Australia compares the value of income resulting from Internet sales of goods or services with total income (excluding extraordinary items). These definitional differences are thought likely to have only a small impact on the comparative results.
6. The **UK income concept** is slightly different to that used in the Australian survey, being a proportion of Internet sales to total sales (rather than Internet income to total income per the Australian treatment). It is thought that this difference is likely to have only a small effect on the analysis.

Appendix B: Additional Organisational Cultures

B-1. Core Culture:

While no organisation has 'one pure culture' throughout, (Schneider W.E. 2000) believes that every successful organisation has a 'core culture' which is critically aligned with the organisation's strategy and its core leadership practices – i.e.: a culture that is central to the functioning of the organisation, forming the nuclear centre for how that organisation operates in order to succeed. As a result the following four 'core cultures' are identified in Table 13-1 (showing their relation between strategy, leadership and central understanding). The four core cultures identified are:

- Control: based on a military system, with power as the primary motive.
- Collaboration: emerging from the family and/or athletic team system, in which the underlying motive is affiliation.
- Competence: derived from the university system, with the fundamental motive of achievement.
- Cultivation: growing from religious system(s) and motivated by growth or self-actualisation.

Table 13-1: 'Core' Cultures

ORGANISATIONAL CULTURE			
CORE	**STRATEGY**	**LEADERSHIP**	**CENTRAL UNDERSTANDING**
Control	• Market-share dominance • Commodity • Commodity-like • High distribution intensity • Life and death • Predictability	• Authoritative • Directive • Conservative • Cautious • Definitive • Commanding	• Certainty • Organisational systematism - the fundamental issue is to preserve, grow, and ensure the well-being and success of the organisation
Collaboration	• Synergistic customer relationship • Close partnership with customer • High customisation • Total solution for one customer • Incremental, step-by-step, relationship with customer	• Team builder • First among equals • Coach • Participative • Integrator • Trust builder	• Synergy • Experiential knowing - the fundamental issue is the connection between people's experiences and reality
Competence	• Superiority • Excellence • Extremely unique • Create market niche • Constant innovation to stay ahead	• Standard setter • Conceptual visionary • Taskmaster • Assertive, convincing persuader • Challenger of others	• Distinction • Conceptional systematism - the fundamental issue is the realisation of conceptual goals, especially superior, distinctive conceptual goals
Cultivation	• Growth of customer • Fuller realisation of potential • Enrichment of customer • Raise the human spirit • Further realisation of ideals, values, higher-order purposes	• Catalyst • Cultivator • Harvester • Commitment builder • Steward • Appeal to higher-level vision	• Enrichment • Evaluation knowing - the fundamental issue is the connection between the values and ideals of the organisation and the extent to which those values and ideals are being implemented

B-2. Culture Tribes:

(Revenaugh D. L. 1994) refers to four 'tribes' of corporate cultures (Figure 13-1 and Table 13-2):

Figure 13-1: Corporate Culture 'Tribes'

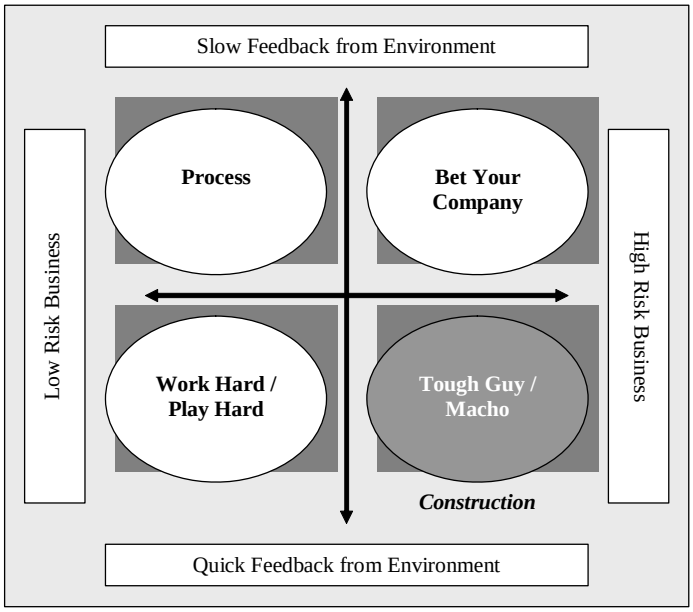

Table 13-2: Corporate Culture 'Tribes' Defined

CORPORATE	
TRIBE	**CULTURE**
Tough-guy / Macho	: Organisations that have a '*high risk / quick feedback*' environment (*find a mountain and climb it)*. Typical industries include advertising, entertainment and ***construction***.
Work hard - Play hard	: Organisations operating in a '*low risk / quick feedback*' environment (*find a need and fill it*). Typical industries include retail and sales.
Bet your company	: Organisations operating in '*high risk / low feedback*' environments (*play it safe*). Typical industries include oil, drugs, aerospace and public utilities.
Process	: Organisations operating in 'low risk / slow feedback' environments (be perfect). Typical industries include banking, insurance and government departments.

B-3. Culture Themes:

Four 'main themes' of organisational culture are identified and discussed in (Maull R., Brown P. et al. 2001):

- Learned entity: the culture is 'taught' to new members of the organisation as 'the correct way to behave', and as a result 'perpetuating organisational survival and growth';
- Belief system: two fundamental beliefs form part of this culture 'theme':
  - Guiding belief: described as the 'nitty-gritty' beliefs of 'everyday life' that rarely change as they are in the 'realm of universal truth' and provide direction to the daily beliefs.

- Daily beliefs: described as the 'rules and feelings of everyday behaviour, continuously changing to match context.
- Strategic: where culture change is described as a strategic change and any strategic formulation is a cultural activity – i.e.: to propose an attempt to implement a 'separate culture change program' within an organisation will fail due to a cultural change already taking place within formal and informal strategic planning processes.
- Mental programming: emphasising this culture is:
  - Collective: with shared values and with no individual characteristics;
  - Mental 'software': invisible and intangible;
  - Interesting: as it differentiates between categories of people.

B-4. Dimensions of Culture:

In (Wallace J., Hunt J. et al. 1999), four 'dimensions' of organisational culture are discussed:

- Individualism: the extent where people orientate towards self-interest (rather than towards the interests of a wider group of which they are part).
- Uncertainty avoidance: the extent of attempting to minimise uncertainties (sooner than the extent of their tolerance of ambiguity levels).
- Power distance: the degree to which relationships between superior and subordinate are distant and formal (rather than close and informal).
- Masculinity: levels of success defined in terms of assertiveness, challenge and ambition (rather than in terms of caring and nurturing).

B-5. Classic v Quantum Culture:

(Youngblood M.D. 2000) states that organisations are machines for producing profit, and people are the cogs of that machine, identifying two types of cultures (Table 13-3):

Table 13-3: Classic v Quantum Culture

COMPARATIVE MEASURES	CULTURE TYPES	
	CLASSIC	**QUANTUM**
Central metaphor	: Machines	: Natural systems
Attitudes towards people	: Must be managed, controlled, not trustworthy; must be given incentive and driven to do good work	: Capable, trustworthy, creative, and committed to doing great work
Strategy	: Centralised, fixed	: Emergent, opportunistic, flexible
Structure	: Hierarchy	: Network
Leadership	: Leaders are rare, heroic people who are all-knowing and who are expected to drive the company to achieve results	: Leadership is a distributed phenomenon; results are achieved by creating an environment where ingenuity, creativity, and responsibility can thrive
Management	: Command and control methods are used to meet planned levels of performance	: Employees operate with a high level of autonomy and are coached to produce extraordinary results in surprising ways
Culture	: Unimportant; given little or no attention	: Vital to success; significant time and energy given to it
Renewal	: Focus on extending existing business model by doing more of what's already being done - only better	: Focus on creating breakthrough innovations that change the rules or create whole new markets
Agility	: Slow, inward focused, unresponsive	: Fast, extremely focused, very responsive
Vitality	: Employee welfare is secondary to financial concerns; motivation through economic benefits	: People are treated equal to or above financial concerns; motivation through an inspiring vision and ability of everyone to contribute

From the above descriptions, it is clear that 'classic cultures' do not suit today's competitive environment as they are unable to deliver the speed, creativity and responsiveness needed to compete effectively. Therefore, unattractive to trained and talented employees required by companies. On the other hand,' quantum cultures' successfully adapted to change by developing new ways of thinking and working (e.g. by implementing innovative ICTs). Thereby producing 'quantum leap' results ahead of most other industry competitors (Youngblood M.D. 2000).

B-6. Culture Metaphors:

(Line M.B. 1999) makes use of the following animal metaphors to describe organisational cultures, identifying the 'cat culture' as the most appropriate for surviving in the 'animal business world' (Table 13-4):

Table 13-4: Animal Cultures

ORGANISATIONAL CULTURES	
METAPHOR	**DESCRIPTION**
Lion	• Leader in its field • Dominating without a great deal of effort
Chimpanzee	• Highly intelligent, aggressive yet co-operating with one another to survive • Constant power struggle – the head therefore can never feel secure.
Bonobos *(pygmy chimpanzee)*	• Easily mixes and bonds with other Bonobos • Flourish only in special habitats • Strong corporate spirit • Endangered
Gorilla	• Gentle • Playful • Non-aggressive • Cohesive • Few internal conflict • Size and appearance frighten others.
Hyena	• Not pleasant • Kills if necessary • Scavenger.
Wolf	• Hunt in packs • Obey leaders • No ability (or wish) to think for themselves • Enduring loyalty • Sense of common and undisputed purpose • Feared by others.
Cow	• Pathetic • Leader (bull) is fearsome yet generally placid • Limited vision • Attacking for no reason • Unadventurous • Limited range of activity and potential.
Sheep	• A powerful ram as a leader to see of rivals in no uncertain manner • No direction • Easily managed • Liable to panic when faced with even imaginary threats • Productive within their own limits.
Elephant	• Long lasting • Provide mutual support • Cannot be bullied • Tend to be undiscriminating and roughly trample over territories.
Cat *(most desirable)*	• Independent • Willing to work in groups – yet comfortable being on their own

	• Flexible • Democratic – deciding on the basis of self interest • Loyal only to themselves • Adaptable • Curious • Will not hesitate to leave • Make their wants felt • Not easy to manage - over management is counter productive producing ‘stagnation’.

Appendix C: Virtual Team Research Propositions

(Furst S., Blackburn R. et al. 1999)

Table 13-5: Virtual Team Research Propositions

RESEARCH PROPOSITIONS	
CATEGORY	**QUESTIONS**
Organisational Context	• How must organisational performance evaluation and compensation systems change to support virtual teams? • How can team-member contributions to team outcomes best be measured, evaluated and rewarded? • How can team outcomes themselves best be measured, evaluated and rewarded? • What should be the role of the information technology, human resource and training function in co-ordinating and supplying the training necessary to use new team-based hardware and software to facilitate team-based virtual environments? • In what types of corporate cultures are virtual teams more likely to flourish? • What types of cultural changes will be necessary for organisations to implement successful virtual teams? • Which way does the causal arrow point? • Will the use of a few virtual teams enable significant cultural change or will existing cultures continue to facilitate or inhibit virtual team success?
Team structure	• What are the characteristics of organisational tasks that make these tasks more or less appropriate for assignment to virtual teams? • Under what task requirements, if any, are co-located group hierarchical and/or communication structures equally appropriate in the virtual environment? • Which task characteristics require which hardware and software technologies for their successful accomplishment by virtual teams?
Group composition	• What team-member knowledge, skills and abilities are necessary for effective virtual team performance? • How should the recruitment, selection and training systems be changed, if at all, to ensure that employees have the requisite knowledge, skills and abilities for effective virtual team membership?
Team norms	• Are norms a more or less important consideration in the virtual team environment than they are with co-located teams? • How do norms develop in virtual teams? • How can norms be effectively reinforced and/or sanctioned in virtual teams? • Because virtual teams function within a restricted communications venue, will more or fewer norms develop around appropriate virtual team behaviours? • What types of behaviours might those norms proscribe? • To what extent will virtual team norms transcend country and cultural borders, if at all? • Will differences in behaviour attributable to culture affect the acceptance of norms in the virtual environment to the same extent that such differences affect norm acceptance in the co-located environment? • To what extent will virtual norms influence the cohesiveness of virtual teams, if at all? • To what extent is cohesiveness an appropriate concept to consider in the virtual environment? • If it is, then how can team cohesiveness best be managed? • What are the most appropriate processes to overcome the cultural barriers that may reduce virtual team effectiveness?
Building team Identity	• To what extent are the socialisation procedures used for co-located group members appropriate for individuals becoming virtual team members? • To what extent do team goals and objectives guide virtual team behaviour? • What is the most effective way to establish agreement upon and

	commitment to team goals in a virtual environment?
Trust	• What are the antecedents of trust in virtual teams, and what are the relative contributions of these antecedents to team trust? • What are the behaviours engaged in by virtual team members that most frequently engender trust and/or mistrust among the virtual team?
Managing team cooperation and heterogeneity	• To what extent does the nature of the technology used in the virtual team environment facilitate or mitigate the potential negative effects of increasing team member heterogeneity? • What mechanisms are available or can be developed to assist virtual teams to resolve conflicts and overcome process losses that might be associated with increased member heterogeneity?
Free riding / social loafing	• Is social loafing/free-riding more or less likely in virtual teams than it is in co-located teams? • What are the antecedents of social loafing or free riding in virtual teams? • What technologies and/or management interventions might be most useful to reduce the likelihood of social loafing or free riding in virtual teams?
Group think and group shift	• Is groupthink or group shift more or less likely in the virtual environment? • Under what conditions might either occur more or less frequently? • Is it more or less difficult to present contrary information or to champion a minority opinion in a virtual team context than in a co-located one? • How does the mode of virtual team interaction (asynchronous compared with synchronous) affect the potential for groupthink or group shift?
Material group resources	• What levels of which types of resources are necessary and/or sufficient for virtual teams to perform effectively? • Although technology obviously has a substantial impact on the success of virtual teams, what determines the appropriate level of technology support personnel to ensure virtual team effectiveness? • In terms of balancing the savings from working virtually (for example, reduced travel cost and overhead expenses) with the costs of doing so (for example, investments in technology and training), what is the break-even point at which virtual teams become more cost-effective than co-located teams? • What is the relationship between each of these resources and virtual team effectiveness? • Is that relationship necessarily linear? • Can virtual teams have too many as well as too few material resources?

Appendix D: e-Solutions

To follow, products and services offered by a diverse range of e-Commerce organisations, including their contact details and website addresses (DCITA 1998):

- **Business Resources for SMEs**
  - Enterprise Market (e.m) (http://www.asx.com.au/e.m): *an Internet service delivered by the Australian Stock Exchange intended to marry capital-poor SMEs with investors and venture capitalists.*
  - Interactive Knowledge On-Line (http://www.iko.com.au/): *provides a wide range of practical, easy to read information on e-commerce that can be freely downloaded from their Internet website.*
  - The Business Centre (http://www.buscentre.com.au/): *provides a free information resource for companies, including: business news, publications, a weekly email newsletter, tools and directories. This enables SMEs to keep up to date with developments and general business news, which they may not have had the time to monitor previously.*
- **Electronic Commerce Associations**
  - Australian Information Industry Association (AIIA) (http://www.aiia.com.au): *a national body representing businesses of all sizes, including SMEs. Membership is open to information technology and telecommunications hardware, software and services companies; telecommunications carriers; multimedia developers; and online services providers.*
  - Australasian Web Publishers' Association Inc. (APWA) (http://www.awpa.asn.au): *a young association with a charter to foster consistent standards within the Internet industry and to promote the development of quality websites within Australasia - relevant to SMEs with an Internet presence, or to individuals who are building or e-commerce enabling a company website.*
  - CommerceNet (http://www.commerce.net & http://www.commercenet.com.au): *a leading global association (with an Australian branch) working to promote Internet commerce, providing a services for a broad spectrum of companies. The website provides a source of information for the businesses wanting an overview of the latest United States trends and developments in e-commerce.*
  - Tradegate ECA (http://www.tradegate.org.au): *a non-profit organisation with a charter to promote e-commerce in Australia and throughout the world.*
- **Electronic Commerce Merchants**
  - Camtech (http://www.camtech.net.au): *provides secure online payment systems for both small and large companies. The website also provides a variety of information and links that would be useful for an SME still exploring the concepts of e-commerce.*
  - NetCommerce™ - Creative Digital Technology (CDT) (http://www.creative.com.au/): *products provide e-commerce tools ranging from an online shopping and catalogue system, to shopping mall technology, to sophisticated systems defining business processes.*
  - St.George Bank- e-Cash (http://www.stgeorge.com.au/ecash): *intended to provide websites with secure low-cost payment systems and a cheaper alternative to the traditional methods of online payment, such as secure credit card transactions.*
  - SecurEcomm (http://www.securecomm.com.au): *provides highly secure e-commerce solutions, aimed at businesses performing online transactions from website content and catalogues.*
  - Telstra SureLink™ (http://www.surelink.com.au): *a well-recognised, heavily promoted and used by approximately 27 merchants with the backing and marketing budget of one of Australia's largest companies.*
- **Electronic Commerce Malls and Service Providers**
  - Austrade Online (http://www.austrade.gov.au): *a service for SMEs who are seeking to increase their international exposure without significant financial outlay. The website's*

relevance to SMEs is boosted by the credibility and visibility of Austrade as an export facilitation agency with an international network of 97 offices.

- ChoiceMall (http://www.choicemall.com): *aimed at providing companies producing unique Australian goods with a showcase in the massive North American online marketplace. The introduction of Australian goods to the site provides the potential for Australian SMEs to introduce their products to the North American market and to increase their export opportunities.*
- SOFCOM (http://www.sofcom.com.au/mall): *offers SMEs the opportunity to participate in e-commerce through its 'do-it-yourself' virtual shopping mall with over 56 online stores and one of the largest Australian based shopping malls.*
- Visa Shopping Guide by Yahoo! Australia & NZ (http://shopguide.yahoo.com.au): *a shopping guide to online stores selling to the consumer market.*
- Yellow Pages (http://www.pacificaccess.com.au & http://yellowpages.com.au/yp/sguide/): *provides a good reference point for SMEs wishing to establish an online e-commerce presence.*

- **Electronic Commerce Training Organisations**
  - Com Tech (http://www.comtech.com.au): *has a wide presence throughout Australia and can provide SMEs with sophisticated technical training on all aspects of Information Technology and the Internet.*
  - Open Learning Australia (http://www.ola.edu.au): *develops and delivers a wide range of training, education and professional development programs orientated to suit varied needs and circumstances.*
  - Southrock Software (http://www.southrock.com.au): *online education and training management facilities are aimed at blue chip companies in Australia, South East Asia and Europe and aimed more towards medium sized organisations (entry pricing of $20,000) that can take advantage of their services.*
- **Government Resources for SMEs**
  - Department of Communications, Information Technology and the Arts (http://www.dcita.gov.au): *contains business material encouraging the development of Australian information technology and telecommunications businesses of all sizes, covering areas such as: relevant agencies, legislation and codes of conduct.*
  - National Office for Information Economy (NOIE) (http://www.noie.gov.au): *responsible for developing, coordinating and over viewing broad Australian government Internet and e-commerce policy, keeping interested SMEs up to date with the latest Government policy and initiatives towards the Internet and e-commerce.*
- **Industry Associations**
  - ABL - Australian Business Limited 'Showcase' and 'Tradehub' (http://www.abol.net & https://www.tradehub.net): *provides a combination of business information and an online electronic catalogue (an affordable and uncomplicated introduction to e-commerce).*
  - CPA Online (http://www.cpaonline.com.au): *provides a wide range of information, ranging from business news, publications, and business advice to information technology and the Internet.*
  - QCCI - Queensland Chamber of Commerce and Industry (Http://www.qcci.net.au/): *educating businesses about the Internet and e-commerce by providing a range of services from building websites to technical and strategic advice on e-commerce.*
  - The Ai Group (http://www.acm.org.au/): *is the peak representative body for manufacturing companies in Australia and as such is pertinent to SMEs operating in the manufacturing sector, publishing business news and information, focusing on manufacturing and exporting and also provides a link to TradePoint (a United Nations initiative intended to make global markets more accessible), thereby offering increased international exposure and export opportunities for SMEs.*
  - VECCI (Victorian Employers Chamber of Commerce and Industry) (http://www.vecci.org.au): *has experience in understanding the needs of SMEs, publishing business information and details of its products and services, covering a diverse range of topics relevant to business.*

- VISA (http://www.visa.com): *SMEs, who are Visa merchants and considering moving into e-commerce, can benefit from Visa's intention to promote secure e-commerce and SET™ as the global standard to its partners, financial institutions, merchants and end user.*

- **Assistance with Technical Implementation**
  - Centris Solutions (http://www.centris.net.au): *provides customised technical solutions to meet client's e-commerce and Internet requirements.*
  - Commercial Interactive Media (http://www.cim.com.au): *an experienced Internet/Intranet developer and integrator of e-commerce software.*
  - e-Business Australia (http://www.ebusiness.com.au): *provides updated information on e-commerce and e-commerce associated topics of interest to an SME investigating this area, including business services, e-commerce consultation, site design, technical solutions and e-commerce education.*
  - ETC - Electronic Trading Concepts (http://www.etc.com.au/): *features a range of links to a comprehensive amount of technical information about e-commerce.*
  - IBM (http://www.ibm.com.au): *targeting small businesses with its e-business solutions, through its highly visible national advertising campaign. IBM holds key relationships with major stakeholders within the IT industry, which should ensure its ability to implement a proper and complete SME Internet solution.*
  - Internet Business Centre Pty Ltd (IBC) (http://www.business.com.au): *Based in Perth, IBC offers a wide variety of technical Internet solutions ranging from Internet publishing to web site hosting to e-commerce solutions.*
  - Naked Software Design Studios (http://www.nakedstudios.com.au): *has a large existing client base (over 150 merchants), and with experience in addressing the requirements of this market place, will be able to assist SMEs who are looking for a technical integrator to create a virtual shop front, electronic catalogue, or to e-commerce enable their website.*
  - Online Trade Management Services (OTMS) (http://www.ontrade.com.au): *aims its services at the SME market, delivering education, consulting, analysis and design.*
  - Somerset Systems (http://www.somerset.com.au): *specialises in sophisticated information solutions for their clients by providing a range of consulting services, which will analyse and develop appropriate software to meet the requirements of large and small businesses, including developing an e-commerce enabled Internet presence.*
  - WebCentral (http://www.webcentral.com.au/): *targeting a range of businesses, particularly SMEs, with its 'do-it-yourself' Internet solutions, offering training seminars aimed at helping SMEs see how the Internet and e-commerce can benefit their businesses.*
  - Zergo (http://www.zergo.com.au): *a supplier of electronic encryption products to ensure confidentiality of information sent over the Internet – i.e.: supply encryption software and hardware and integrate them into a company's existing information and communication system infrastructure.*

14 AUTHOR BIBLIOGRAPHIES

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Dr Kajewski is a senior lecturer with the School of Construction Management & Property at the Queensland University of Technology and is presently the A/Head of School of Construction Management & Property and the Course Coordinator for the Master of Project Management degree. Dr Kajewski is presently the Project Manager for a number of major research projects concerning the adoption and use of information and communication technology (ICT) being conducted in conjunction with the University, Government, and Industry. The combined funded and in-kind value of these projects is exceeds A$1.2M and while all different, they are based around the aim of developing and demonstrating leadership in facilitating the use of online technologies for the design, management and construction of building and civil construction projects by identifying and implementing ICT solutions that will improve resource management; support and integrate total project life cycle considerations; increase efficiencies on projects, ultimately reducing overall cost; and improving project outcomes to project participants in the public and private sectors.

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Mr Weippert is presently undertaking a PhD to identify key ‘drivers’ or ‘enablers’ of ICT uptake within ‘virtual’ building and civil project team environments. He is also a Research Assistant to Dr Stephen Kajewski (Project Leader) for the Cooperative Research Centre – Construction Industry (CRC-CI) research project 2001-008-C: ‘Project Team Integration - Communication, Coordination and Decision Support’. Prior to this appointment, he was Research Assistant to Dr Stephen Kajewski (Project Manager) on the Online Remote Construction Management (ORCM) research project. The ORCM project was a major research project undertaken by the Queensland University of Technology (QUT) and Commonwealth Scientific Industrial Research Organisation (CSIRO) Construction Research Alliance (CRA), based at QUT, Brisbane, Queensland, Australia.